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- 1 Memoirs of the American Academy of Arts and Sciences:
to the end of the year M,DCC,LXXXIII. Volume I.
Boston, M,DCC,LXXXV. [1785].
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Academy. - Statutes and list of members, p.
[xii]-xxii. - Errata.--p. [569-570].
- 2 A general index to the Monthly review, from its
commencement, to the end of the seventieth volume. By
the Rev. S. Ayscough, ... In two volumes. ...
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MEMOIRS
OF THE
AMERICAN ACADEMY
OF
ARTS
AND
SCIENCES:

TO THE END OF THE YEAR M,DCC,LXXXIII.

VOLUME I.



BOSTON:
PRINTED BY ADAMS AND NOURSE, IN COURT-STREET.
M,DCC,LXXXV.

MEMOIRS
OF THE
AMERICAN ACADEMY



BOSTON:
PRINTED BY ADAMS AND GORSE, COURT-STREET.
MDCCLXXXV.

P R E F A C E.

MANKIND have ever found a state of society subservient to their comfort and happiness. Subjected to many wants, they have been able, by an union one with another, to obtain that supply, which would have been impracticable if each individual had stood alone ; and invariable experience has taught, that the social bond is the greatest security against the numberless dangers and difficulties, to which they are exposed. Hence the many political or civil institutions, that have been formed in the world, which have been greater or less blessings to the persons, who have belonged to them, in proportion as those institutions have been framed with more or less wisdom, and the members of them have been more or less virtuous and prudent.

Societies for promoting useful knowledge may be highly advantageous to the communities, in which they are instituted. Men united together, and frequently meeting for the purpose of advancing the sciences, the arts, agriculture, manufactures and commerce, may oftentimes suggest such hints to one another, as may be improved to important ends : and such societies, by being the repositories of the observations and discoveries of the learned and ingenious, may, from time to time, furnish the world with useful publications, which might otherwise be lost : for men of ingenuity, and modesty, may not chuse to risk their reputation, by sending abroad, unpatronized, what a learned society might judge richly worthy the public eye ; or, perhaps, their circumstances being straitened, they may not be able to defray the expence of publication. Societies instituted for promoting knowledge, may also be of eminent service, by exciting a spirit of emulation, and enkindling those sparks of genius, which otherwise might forever have been concealed ; and if, when possessed of funds sufficient for the purpose, they reward the exertions of the industrious and enterprising, with pecuniary premiums or honorary medals, many important experiments and useful discoveries will be made, from which, the public may reap the highest advantages.

Eminent instances of the beneficial effects of such institutions we have, in the Royal Academy of Sciences at *Paris*, the Royal Society, and the Society instituted for the encouragement of Arts,
Manufactures

Manufactures and Commerce, in *London*, and many others of a similar kind, in *Europe*. Hereby a spirit of discovery and improvement has been excited among the ingenious, in almost every nation, in that quarter of the world; and knowledge of various kinds, and greatly useful to mankind, has taken place of the dry and uninteresting speculations of schoolmen; and bold and erroneous hypothesis has been obliged to give way to demonstrative experiment. In short, since the establishment of these societies, solid learning and philosophy have more increased, than they had done for many centuries before.

But the spirit of promoting knowledge, by instituting literary societies, has not been confined to *Europe*: It has found its way to *America*. Some years ago, a number of gentlemen in *Philadelphia*, voluntarily formed themselves into a society, by the title of, *The American Philosophical Society*. They have published one volume of transactions, which has done them honor.

In this Commonwealth, a society for promoting useful knowledge was, for many years, in contemplation; but the design was never vigorously engaged in and pursued, 'till the end of the year 1779, when many gentlemen, persuaded of the utility of such an institution, determined, without delay, to use their endeavors, to have one formed upon a liberal and extensive plan, and at the same time, to have it established upon a firm basis, by obtaining the sanction of the Legislature. And to the honor of our political Fathers be it spoken, that although the country was engaged in a distressing war, a war the most important to the liberties of mankind, that was ever undertaken by any people, and which required the utmost attention of those, who were entrusted with our public concerns, they immediately adverted to the usefulness of the design, entered into its spirit, and incorporated a society, with ample privileges, by the name of, *The American Academy of Arts and Sciences*. The purpose of this institution is to promote most branches of knowledge advantageous to a community, as will appear, by the following charter of incorporation, which was granted May 4, 1780.

“An Act to incorporate and establish a Society for the cultivation and promotion of Arts and Sciences.”

“AS the Arts and Sciences are the foundation and support of agriculture, manufactures, and commerce; as they are necessary to the wealth, peace, independence and happiness of a people; as they essentially promote the honor and dignity of the government which patronises them; and

as

P R E F A C E

“ as they are most effectually cultivated, and diffused through a State,
 “ by the forming and incorporating of men of genius and learning into
 “ public societies : For these beneficial purposes,

“ Be it therefore enacted by the Council and House of Representatives in
 “ General Court assembled, and by the authority of the same, That the
 “ Hon. Samuel Adams, Esq; Hon. John Adams, Esq; John Bacon,
 “ Esq; Hon. James Bowdoin, Esq; Rev. Charles Chauncy, D. D. Rev.
 “ John Clark, David Cobb, Esq; Rev. Samuel Cooper, D. D. Hon.
 “ Thomas Cushing, Esq; Hon. Nathan Cushing, Esq; Hon. William Cush-
 “ ing, Esq; Tristram Dalton, Esq; Hon. Francis Dana, Esq; Rev.
 “ Samuel Deane, Rev. Perez Fobes, Rev. Caleb Gannett, Hon. Henry
 “ Gardner, Esq; Mr. Benjamin Guild, Hon. John Hancock, Esq; Hon.
 “ Joseph Hawley, Esq; Edward Augustus Holyoke, Esq; Dr. Ebenezer
 “ Hunt, Jonathan Jackson, Esq; Dr. Charles Jarvis, Rev. Samuel
 “ Langdon, D. D. Hon. Levi Lincoln, Esq; Rev. Daniel Little, Rev.
 “ Elijah Lothrop, John Lowell, Esq; Rev. Samuel Mather, D. D. Samuel
 “ Moody, Esq; Hon. Andrew Oliver, Esq; Dr. Joseph Orne, Dr.
 “ Theodore Parsons, Hon. George Partridge, Esq; Hon. Robert Treat
 “ Paine, Esq; Rev. Phillips Payson, Samuel Phillips, jun. Esq; Hon.
 “ John Pickering, Esq; Hon. Oliver Prescott, Esq; Rev. Zedekiah
 “ Sanger, Hon. Nathaniel Peaslee Serjeant, Esq; Micajah Sawyer, Esq;
 “ Theodore Sedgwick, Esq; Hon. William Sever, Esq; Stephen Sewall,
 “ Esq; Hon. David Sewall, Esq; John Sprague, Esq; Ebenezer Storer,
 “ Esq; Caleb Strong, Esq; Hon. James Sullivan, Esq; Dr. John Bernard
 “ Sweat, Mr. Nathaniel Tracy, Cotton Tufts, Esq; Hon. James Warren,
 “ Esq; Rev. Samuel West, Rev. Edward Wigglesworth, Rev. Joseph
 “ Willard, Rev. Samuel Williams, Rev. Abraham Williams, Rev. Nehemiah
 “ Williams, and Mr. James Winthrop, be, and they hereby are formed
 “ into, constituted and made a Body Politic and Corporate, by the
 “ name of THE AMERICAN ACADEMY OF ARTS AND SCIENCES ;
 “ and that they and their successors, and such other persons as
 “ shall be elected in the manner hereafter mentioned, shall be, and
 “ continue a Body Politic and Corporate, by the same name forever.

“ And be it further enacted by the authority aforesaid, That
 “ the Fellows of the said Academy may from time to time
 “ elect a President, one or more Vice Presidents, one or more
 “ Secretaries, and such other Officers of the said Academy, as they
 “ shall judge necessary or convenient ; and they shall have full
 “ power and authority from time to time to determine and esta-
 “ blish the names, number and duties, of their several officers, and
 “ the tenure or estate they shall respectively have in their offices ;
 “ and also to authorize and empower their President, or some
 “ other

“ other Fellow of the Academy, at their pleasure, to administer
“ such oaths to such officers as they shall appoint and determine,
“ for the well ordering and good government of the said Academy :
“ provided the same be not repugnant to the laws of this State.

“ *And be further enacted by the authority aforesaid,* That the Fellows
“ of the said Academy shall have one common seal, which they
“ may make use of in whatsoever cause or business shall concern
“ the Academy, or be relative to the end and design of its institu-
“ tion ; and shall have power and authority from time to time
“ to break, change, and renew the common seal, at their pleasure ;
“ and that they may sue and be sued in all actions, real, personal
“ and mixed, and prosecute and defend the same unto final judg-
“ ment and execution, by the name of, The President and
“ Fellows of the *American* Academy of Arts and Sciences.

“ *And be it further enacted by the authority aforesaid,* That the
“ Fellows of the said Academy may from time to time elect such
“ persons to be Fellows thereof, as they shall judge proper ; and
“ that they shall have full power and authority from time to time,
“ to suspend, expel or disfranchise, any Fellow of the said Acade-
“ my, who shall by his conduct render himself unworthy of a
“ place in that body, in the judgment of the Academy ; and also
“ to settle and establish the rules, forms and conditions of election,
“ suspension, expulsion and disfranchisement. *Provided,* That the
“ number of the said Academy, who are inhabitants of this State,
“ shall not, at any one time, be more than two hundred, nor less
“ than forty.

“ *And be it further enacted by the authority aforesaid,* That the Fel-
“ lows of the said Academy shall have full power and authority
“ from time to time, to make and enact such reasonable rules, or-
“ ders and bye-laws, not repugnant to the laws of this State, as
“ shall be necessary or convenient for the well ordering and good
“ government of the said Academy ; and to annex reasonable pe-
“ cuniary fines and penalties to the breach of them, not exceeding
“ the sum of *twenty pounds*, to be sued for and recovered in any
“ Court of record within this State, in the name and for the use
“ of the President and Fellows of the said Academy ; and the
“ same rules, orders and bye-laws to repeal at their pleasure : And
“ also to settle and establish the times, places, and manner of con-
“ vening the Fellows of the said Academy : And also to deter-
“ mine the number of Fellows which shall be present, to consti-
“ tute a meeting of the said Academy. *Provided,* That the Fel-
“ lows of the said Academy shall meet twice in a year at the least ;
“ and

“and that the place of their meeting shall never be more than thirty miles distant from the town of *Boston*.

“*And be it further enacted by the authority aforesaid*, That the Fellows of the said Academy may, and shall forever hereafter be deemed capable in the law of having, holding, and taking in fee-simple, or any less estate, by gift, grant, devise or otherwise, any lands, tenements, or other estate, real and personal: *Provided*, That the annual income, of the said real estate, shall not exceed the sum of *five hundred pounds*, and the annual income or interest of the said personal estate shall not exceed the sum of *two thousand pounds*. All the sums aforementioned in this act to be valued in silver, at the rate of *six shillings and eight-pence* by the ounce. And the annual interest and income of the said real and personal estate, together with the fines and penalties aforesaid, shall be appropriated for premiums to encourage improvements and discoveries in agriculture, arts and manufactures, or for other purposes, consistent with the end and design of the institution of the said Academy, as the Fellows thereof shall determine.

“*And be it further enacted by the authority aforesaid*, That the end and design of the institution of the said Academy is, to promote and encourage the knowledge of the antiquities of *America*, and of the natural history of the country, and to determine the uses to which the various natural productions of the country may be applied; to promote and encourage medical discoveries, mathematical disquisitions, philosophical enquiries and experiments; astronomical, meteorological and geographical observations; and improvements in agriculture, arts, manufactures and commerce; and in fine, to cultivate every art and science, which may tend to advance the interest, honor, dignity and happiness of a free, independent and virtuous people.

“*And it is further enacted*, That the place where the first meeting of the Fellows of the said Academy shall be held, shall be the Philosophy Chamber in the University of *Cambridge*; and that the Honorable *James Bowdoin*, Esq; be, and he hereby is authorised and empowered to fix the time for holding the said meeting, and to notify the same to the Fellows of the Academy.”

Such is the basis, upon which this institution is placed.

Not many months after this act of incorporation was passed, the statutes were formed, the body became organized, and communications were received. From the communications till the end of the year 1783, the following volume is now offered to the public. This

This country being young, and few among us having such affluence and leisure as to admit of their applying much time to the cultivation of the sciences, and to the making of improvements in arts, manufactures, agriculture, &c. it will not, at present, be expected, that this Academy should vie with similar institutions in old countries, where they have peculiar advantages for such prosecutions. Yet, it is hoped, that the following papers will not be reckoned useless, nor prove unacceptable to the public.

The astronomical and mathematical papers, in this volume, will, perhaps, be the least entertaining of any in the collection, and will have the smallest number of readers. However, they are useful in such a work. Few, if any of them, contain deep speculations and obscure researches and calculations; but they are chiefly of the practical kind. The astronomical pieces principally exhibit such observations and deductions, as are subservient to the cause of geography and navigation, the improvement of which is of great importance to this country. And as astronomical observations may be applied to ends so valuable, it is earnestly to be wished, that every gentleman capable of it, would improve every opportunity to make them with accuracy, and when made, would kindly communicate them to the Academy. These, and all mathematical pieces, will be gratefully received, and due attention paid to them, by this body.

To some readers, the subject of many papers, which have a place in the physical part, may seem unimportant; but it ought to be remembered, that one interesting pursuit of the Academy is the natural history of their own country;—a country, where the arts of defence and the means of subsistence have, hitherto, almost engrossed the industry of its inhabitants; where the fossil and vegetable kingdoms are yet unexplored, and perhaps, their most valuable productions still undiscovered.

It is the part of a patriot-philosopher to pursue every hint—to cultivate every enquiry, which may eventually tend to the security and welfare of his fellow citizens, the extension of their commerce, and the improvement of those arts, which adorn and embellish life. Nor can such traces and vestiges, as may occur, of the manners and resources of its aboriginal inhabitants, be unworthy the collection. Besides the idea thus excited of the condition of man in savage life, the present inhabitants of the same climate and soil may thereby, in some way or other, occasionally receive hints, which may be improved to their own advantage. This principle, which has govern-

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ed the Academy in making the selection, will account for the introduction of some articles, relating to the natural history of the country.

Many pursuits, in various branches of natural philosophy, are retarded, by the difficulty of obtaining that variety of instruments, which can be had only from those countries, where the manufactures, which minister to the arts, are established in perfection. But this difficulty, it is hoped, will daily lessen, and ere long, entirely cease.

The medical papers may, probably, contain many observations not entirely new. However, this ought not to be considered a sufficient objection to their being inserted in this work, because many important discoveries in pathology, as well as in the animal œconomy, have been in a great measure useless to this part of the world, in consequence of a situation so remote from ancient seats of learning and improvement. And of such publications as have reached this country, the smallness of the number has greatly limited their usefulness, as but few have had opportunity for perusing them. In points merely speculative, this inconvenience has been less consequential; but, in practical science, deeply to be regretted. A long war, in which these States were engaged, destroyed, for a time, that intercourse, by means of which, books on the various arts and sciences, and such as contained the most modern discoveries and improvements, had usually been obtained. The contents of some of these papers, therefore, though they may afford nothing new to the *European*, yet, to many *American* readers may have the recommendation of novelty.

It may be further remarked, that although the novelty of an opinion or discovery may, sometimes, more advance the fame and honour of the author, yet, that there are known facts, of such a nature, that the repetition of them, in publications of this kind, may be no less useful to the world, as they may thereby be more forcibly impressed upon the mind, and conveniently adverted to, in common practice.

Upon these principles the Academy conceived it to be their indispensable duty to publish, by means best adapted to the purpose of diffusing their utility, such experiments and observations, as, though not new, yet, not having been sufficiently attended to, may be more extensively applied towards perfecting the present modes of practice in this country, as well as to communicate, by the earliest opportunities, such discoveries, as may lead to the investigation of important phenomena, in the animal œconomy.

It is obvious that the following work is well calculated for answering these intentions. The circulation of it will be principally confined to these States; and as a repository of miscellaneous papers on the subject of physic and surgery, it will, doubtless, generally fall into the hands of gentlemen of the faculty in this country; a circumstance, which will very rarely take place, with respect to any publication imported from abroad.

The Members of the Academy are disposed to do every thing in their power to promote the designs of the institution; but they are sensible, that much aid is wanted from others; and they are happy to have it in their power to acquaint the public, that from the number of valuable communications, which have been made by gentlemen in various parts of the country, there is reason to expect, that their assistance will be continued, and such materials furnished, as will not be unworthy the notice of the public, which it is the sincere wish of the Academy to serve. And from that expectation; and the great encouragement given to the printing of this volume, they have the pleasing prospect, that they shall be able to publish a succession of volumes. The papers they now have in their hands will go a considerable way towards another; and they doubt not, they shall soon have sufficient to complete it.

There is now an ample field opened, in this country, in which the ingenious may expatiate; and men of various turns of mind may employ their leisure, not only to their own amusement and improvement, but also to the emolument of the community.

Agriculture stands in great need of attention. As the solid prosperity of the country will much depend upon the cultivation of our lands, too much regard cannot be paid to this subject. To examine the various soils, and determine what each is best adapted to produce; to ascertain the most suitable manures, and the means of increasing them; to devise methods to secure the fruits of the field, and of the trees from blights and destructive insects, will afford a fine opportunity for experiments, which, it is hoped, will engage the minds of the curious and inquisitive, and meet with encouragement from gentlemen of property.

The genius for natural history may have a large range, as the fossil, the vegetable and animal kingdoms, in this part of the world, lie before him.

There will be ample room for the researches of the Botanist and Chymist, who, while they pursue their respective branches, may greatly contribute to the advancement of the healing art, which is of the highest importance to the inhabitants of a country.

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The labors of the Astronomer are much needed, and will be peculiarly useful,—particularly those observations and calculations, which will serve to perfect the geography of the country, and improve navigation, as has before been intimated. Hereby, the boundaries between one State and another in the Union, may be accurately determined, and disputes prevented or settled; the latitudes and longitudes of our sea-ports and head lands ascertained, and our intercourse with foreign nations facilitated.

The various mechanical arts and manufactures, together with commerce, require peculiar attention and cultivation; and much may be expected, from that spirit of enterprise, which our citizens are known to possess. Happily, they who are engaged in these several branches of business may mutually aid each other; and every improvement they make, will tend to enrich and aggrandize these confederated States.

But this preface would far exceed the proper limits, should all those branches of business and of science be pointed out, which ought to be attended to and cultivated, by the inhabitants of these States. Let it only be added, that, settled in an extensive country, bordering upon the ocean, and open to a free intercourse with all the commercial world—A country comprehending several climates and a rich variety of soils, watered and fertilized by a multitude of springs and streams, and by many grand rivers, some of them admitting of a fine inland navigation,—the citizens have great opportunities and advantages for making useful experiments and improvements, whereby the interest and happiness of the rising empire may be essentially advanced. At the same time, enjoying, under a mild but steady government, that freedom, which excites and rewards industry, and gives a relish to life—That freedom which is propitious to the diffusion of knowledge, which expands the mind, and engages it to noble and generous pursuits,—they have a stimulus to enterprise, which the inhabitants of few other countries can feel. May they ever be as virtuous and industrious as they are free! May a spirit for advancing every kind of knowledge, that can redound to their honor, and promote the emolument and happiness of themselves and their country, more and more prevail! And may all their laudable endeavors, to further the good of mankind, be crowned with success adequate to their highest wishes!

November 16, 1785.



S T A T U T E S
O F T H E
A M E R I C A N A C A D E M Y O F A R T S A N D S C I E N C E S.

C H A P T E R I.

Of Officers, and the manner of their election.

1. **T**H E R E shall be a President, one Vice-President, ten Counsellors, two Secretaries, a Treasurer, a Vice-Treasurer, and a Keeper of the Cabinet : which officers shall be annually elected by written votes on the day next preceding the last Wednesday in May.

2. In order to this election, the President, or in his absence the Vice-President, or in the absence of the President and Vice-President, the senior Counsellor present shall take the chair, at three o'clock, P. M. and after the choice of three scrutineers by nomination, the ballot shall begin and remain open till five o'clock, at which time it shall be closed ; upon which, should it appear in any instance that there is no choice, the balloting shall be renewed till a choice is made.

3. Each Elector shall deliver his balloting list, folded, to the President, and a scrutineer, sitting by the President with a list of the Members of the Academy present before him, shall mark the name of each person so delivering in his list.

4. When the ballot is closed, the scrutineer shall sort the votes, and report the same to the chair ; after which, the presiding member shall declare the persons, who have the majority of votes, to be the officers respectively for the ensuing year.

5. If either of the Secretaries, the Treasurer, or the Keeper of the Cabinet die, resign, or be removed during the year, at the next meeting of the Academy the vacant office or offices shall be filled by written votes for the remaining part of the year.

6. A t

6. At all elections of officers, if the suffrages should be equal, the decision shall be by lots prepared by the scrutineers, and drawn by the President.

7. Notwithstanding the election of officers be annual, the Academy reserve to themselves a power of removing any of them for neglect of their trust, or disobedience to the orders of the Academy.

8. A Messenger may be appointed or removed at any meeting of the Academy.

C H A P. II.

Of the President and Vice-President.

1. THE business of the President, or in his absence of the Vice-President, or in the absence of the President and Vice-President, then of the senior Counsellor present, shall be to preside in the meetings, and to regulate the debates of the Academy and Council; to state and put questions both in the affirmative and negative, according to motions regularly made; to call for reports and accounts from Committees and others; to preserve decorum; to summon all meetings of the Council, and all extraordinary meetings of the Academy, by advice of Council, upon any urgent occasions; and to execute or to see to the execution of the statutes of the Academy.

2. The President, or in his absence the Vice-President or presiding Counsellor, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct.

C H A P. III.

Of the Council.

1. THE Council shall have full authority, and it is their incumbent duty, from time to time, to originate such laws, statutes, orders and constitutions, as shall appear to them to be necessary or useful, according to their judgment and discretion, for the regulation, government, and promotion of the design of the Academy: all which laws, statutes, orders and constitutions, shall be by them presented at a meeting of the Academy for the approbation of the Fellows; also to prepare such other matters as they may judge proper to be pursued by the Academy, in order to advance in the best manner the end of its institution. Nevertheless, no Fellow is
hereby

hereby precluded from laying before the Academy such matters, or proposing such laws, as he shall think conducive to its benefit.

2. The Council, with the President and Treasurer, have power to make conclusive bargains for real or personal estate, for the benefit of the Academy, and to rent the same, and to give orders concerning the improvement of the estate, goods, lands and revenues of the Academy, pursuant to the orders of the Academy.

3. Every deed or writing to which the common seal is to be affixed, shall be passed and sealed in Council, and signed by the President, and four, at the least, of the Council.

4. During the recesses of the Academy, the Council shall direct the Secretaries in such correspondence as they shall find expedient. The whole of which shall be laid before the Academy at its next meeting.

5. The Council shall order such papers and letters to be recorded as they shall think proper.

C H A P. IV.

Of the Secretaries.

1. ONE of the Secretaries shall have the charge and custody of the Charter and Statute-Book, Journal-Books, Register-Books, and all literary papers belonging to the Academy; and also all letters, after they have been recorded, shall be kept by him on file. This Secretary, if possible, shall attend at all meetings of the Academy and Council, where, when the presiding member hath taken the chair, he shall read the orders and entries of the last precedent meeting, and shall take notes of the orders and transactions of the present meeting, to be entered by him in the respective books, to which they relate. And when there shall be a competent number for making elections, he shall give notice of any candidates that shall stand propounded in order to election into the Academy.

2. The other Secretary shall have the charge and custody of the letter-books belonging to the Academy. He shall attend all meetings of the Academy and Council, and read all letters sent to the Academy, or to any member in his academical capacity, and draw up all letters to be written to any persons in the name of the Academy or Council (to be read and approved of in some meeting of either, respectively) except for some particular cause and consideration, some other person or persons be appointed by the Academy or

of Council, to draught any such letter. He shall also enter all letters that shall be directed by the Academy or the Council, and when entered, the originals shall be delivered to the first-mentioned Secretary in order to their being filed.

3. At every meeting of the Academy, the Secretary, in whose custody the letter-books are, shall read any entries that the presiding member shall direct; and the Secretary, in whose custody the originals are, shall have with him, ready to produce, the file of all letters received since the last precedent meeting, that, if it be required, a comparison may be made.

4. Each Secretary shall deliver an attested copy of any transaction of the Academy, or paper belonging to his particular department, to any member, upon his producing a written licence from the Council for that purpose; and to any other person, who shall produce a licence from the Academy signed by the presiding member, and in no other case whatever.

5. Whenever any copy shall be delivered by a Secretary, the person, upon receiving it, shall pay him such fees as the Academy may establish.

C H A P. V.

Of the Treasurer and Vice-Treasurer.

1. THE Treasurer and Vice-Treasurer shall give such security as the Academy shall require for the trust reposed in them respectively.

2. The Treasurer shall receive officially all monies or sums of money due or payable, and all bequests and donations that may be made to the Academy: and by order of the President or presiding member, shall pay such sums as the Academy or the Council shall direct, pursuant to the orders of the Academy, and shall make no disbursements of money otherwise, and shall keep a particular account of such orders, receipts, and payments.

3. All monies or sums of money whereof there shall not be present occasion for expending, or disposing to the use of the Academy, shall be put out to interest on such securities, or otherwise disposed of as the Academy, or the President and Council, pursuant to the orders of the Academy, shall direct.

4. The Treasurer's accounts shall be annually audited by a Committee appointed by the Academy for that purpose. In which appointment not more than one member of the Council shall be included.

5. In

5. In case of the death, resignation or removal of the Treasurer, the Vice-Treasurer is empowered to receive all books, papers, and effects, that were in the custody of the Treasurer, and which belong to the Academy, and to give receipts and discharges for the same in the name of the Academy. A duplicate of which signed by the Vice-Treasurer shall be filed with the President. The same process shall be observed upon the choice of a new Treasurer, and his acceptance of the office.

C H A P. VI.

Of the Keeper of the Cabinet.

1. THE Keeper of the Cabinet shall receive and have in his charge and custody, all productions of nature and works of art, that shall be purchased by, or presented to the Academy. He shall arrange them according to their respective classes in natural history, philosophy, &c. at his own discretion; unless he be directed therein by a Committee of the Academy for that purpose. He shall also, in a book, to be kept by him, register the various articles in classes corresponding to the arrangement of the Articles themselves, with the description that may accompany the article, the donor's name, and the place whence taken; and the time when presented.

2. He shall attend the exhibitions of the articles in his custody, whenever the Academy shall meet; and no person shall be admitted to a view of them at any other time, unless in presence of the Keeper of the Cabinet, or some member appointed by the Council for that purpose.

3. He shall be Librarian to the Academy 'till they shall judge it expedient to appoint a distinct person to that office.

4. He shall give such security as the Academy shall judge proper for the faithful discharge of his office, and for surrendering the articles in his custody, whenever required by the Academy.

C H A P. VII.

Of the Meetings of the Academy and Council.

1. THERE shall annually be four stated meetings of the Academy, viz. On the last Wednesday in January, and the day next preceding the last Wednesday in May, at Boston, and on the Wednesday

Wednesday next preceding the last Tuesday in *August*, and the second Wednesday in *November* at the University in *Cambridge*. Provided that in case the President shall at either of the said annual meetings, within the year of his first appointment, think proper to deliver, before the Academy, an inaugural oration or philosophical discourse, the place of such meeting may be at *Boston* or *Cambridge*, according as it shall be most convenient to him: of which he shall give notice at some preceding meeting of the Academy.—The Council shall also meet four times annually, viz. On the first Wednesday in *January*, and the first Wednesday in *May*, at *Boston*; and on the first Wednesday in *August*, and the third Wednesday in *October*, at *Cambridge*: unless it should by any means be unsafe for the Academy or Council to convene at either of the places above-mentioned, at the times specified. In which case the President with the advice of the Council, may appoint the next stated meeting of the Academy, at any place within thirty miles distance from *Boston*; and the President in the abovementioned case may appoint a meeting of the Council within the above said limits.

2. Extraordinary meetings of the Academy may be called at any time or place within thirty miles distance from *Boston*, by the President with the advice of the Council. And extraordinary meetings of the Council may be called by the President within the aforesaid limits, whenever he shall judge it necessary.

3. Eleven Fellows shall be present to constitute a meeting of the Academy, unless for the purposes of receiving communications, and adjourning, in which cases, seven shall be a quorum. And at any meeting of the Council the presiding member, with four others of the Council, are required to be present, in order to transact any business proper to the Council.

4. At all meetings of the Academy or Council the President, and Vice-President, or in their absence, the presiding member shall have a right to vote in common with the other members of either body respectively.

5. No person shall be introduced to any meeting of the Academy but by vote of the Academy, except *American* and foreign Ambassadors, members of Congress, members of the Supreme Legislative and Executive of the State of *Massachusetts* for the time being, and members of similar institutions with this Academy, who may be introduced by any member of the Academy.

6. All meetings of the Academy shall be advertised in two at least of the public news-papers, fourteen days previous to such meeting, by one of the Secretaries under direction of the President, or in his absence of the Vice-President, or presiding member of the Council.

7. All meetings of the Council shall be notified to the several members by billets from the President, or one of the Secretaries under direction of the President, or in his absence, of the Vice-President or presiding member of the Council, seven days at least, before the time stated or proposed for a meeting.

C H A P. VIII.

Of Fellows.

1. NO person shall be elected a Fellow of the Academy, unless proposed and recommended by one or more of the members, nor nominated to the Academy until he has first been proposed to the Council, and they have consented to such nomination; and the name, place of abode, and addition of the person recommended, shall be delivered in, signed by the proposers, and read by one of the Secretaries. A fair copy of such paper, with the date when delivered, shall be hung up in the room, where the Academy shall from time to time meet, on which the Candidates may be balloted for at the next, or some succeeding meeting. And if three-fourths of the Fellows then present shall ballot in his favor, he shall be a member.

2. Each Fellow residing in the State of *Massachusetts*, shall be subject to an annual payment of *Spanish* milled dollars in specie, or an equivalent in bills of the current exchange. Fellows without the State shall be subject to no other annual payment, than they voluntarily consent to.

C H A P. IX.

Of Proceedings on literary Performances.

1. THE Academy will never give their judgment or opinion, upon any literary performances presented to them, but allow it to rest upon its own merit, and the credit of its author.

C H A P. X.

Of Oaths.

1. THE President, Vice-President, Counsellors, Secretaries, Treasurer, Vice-Treasurer and Keeper of the Cabinet, shall each take the following oath, *mutatis mutandis*:

I A. B. elected to the office of _____ in the American Academy of Arts and Sciences, do swear, that I will, according to my best judgment and discretion, faithfully discharge the duties of the trust reposed in me.

So help me G O D.

An Explanation of the Plate in the title Page.

THE principal figure in it is Minerva. At her right-hand is a field of Indian Corn, the native grain of *America*. The prospect on that side is bounded by an hill, crowned with Oaks. On the declivity of the hill, towards the sea, appears the out-skirt of a town, the body of which is concealed by the hill. About the feet of Minerva are scattered several instruments of husbandry. On her left-hand are a quadrant and a telescope, a prospect of the sea, with a ship steering towards the town; and the sun rising, and appearing compleatly above the cloud, in which it rose. Over the whole, the motto SUB LIBERTATE FLORENT.

The device represents the situation of a new country, depending principally on agriculture: but attending at the same time to arms, commerce, and the sciences. The sun above the cloud represents, not only our political state in 1780, when the Academy was first incorporated, but also the rising state of *America*, in regard to empire, and the arts and sciences.

The motto conveys the general idea, that arts and sciences flourish best in free States.



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C O N T E N T S.

A PHILOSOPHICAL DISCOURSE, *publicly addressed to the American Academy of Arts and Sciences, in Boston, on the eighth of November, 1780; when the President was inducted into Office.* By JAMES BOWDOIN, Esq; President of the Academy.—Preliminary.

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- A view of society and manners in *Italy*. By Ditto, 2 vols.
- Select essays on commerce, agriculture, mines, fisheries, &c.
- The philosophical history and memoirs of the Royal Academy of Sciences at *Paris*. By JOHN MARTYN, F. R. S. 5 vols.
- The elements of botany. By HUGH ROSE.
- Pyritologia. By J. T. HENCKEL.
- The history of *America*. By WILLIAM ROBERTSON, D. D. 3 vols.
- A preparation of an adult subject; the vascular system injected; and many of the muscles in their natural situation.
- JOSIAH QUINCEY, Esq.** A legacy of one hundred pounds, lawful money.

Various other articles have been presented, chiefly fossil substances. These, with the donors, may be particularly noticed in a future publication; when, after being properly assayed, a more satisfactory account may be given of them than can be at present.



A
PHILOSOPHICAL DISCOURSE,
PUBLICLY ADDRESSED TO THE
AMERICAN ACADEMY OF ARTS AND SCIENCES,

*In Boston, on the eighth of November, M,DCC,LXXX: when
the PRESIDENT was inducted into Office.*

BY JAMES BOWDOIN, ESQUIRE,
PRESIDENT of the ACADEMY.

GENTLEMEN of the AMERICAN ACADEMY of ARTS and SCIENCES!

WHEN I consider, that among the members of the Academy there are gentlemen of abilities superior to my own, especially in the walks of philosophy, I feel a consciousness, that its honours might in one instance have been better placed. But if a defect of abilities could be compensated by a good will to serve its interest, and promote the end of its institution, I should have the satisfaction to think myself not wholly unqualified for the station, with which your suffrages have honoured me.

It is in discharge of the duties of it, that I appear in this place: and in the discharge of them, both at present and on future occasions, as I greatly need it, so I doubt not I shall always experience your candour:—the candour, which ever accompanies generous minds, and is the result of the due exercise of the social affections.

The social affections in man are the principal source of his
E happiness;

N.B. At the desire of the Academy, expressed by their vote of the 8th of November, 1780, this Discourse was soon after published.

happiness ; and the operation of them, as directed by his wants, and other circumstances, forms his connections in society. Their first objects, in the order of nature, are our relations and near friends ; next to these our neighbours and countrymen succeed ; then the people of other countries, in political connection with us ; and in the last place, mankind in general. In proportion, however, as these objects are more remote, those affections are the less powerful. After operating on their first objects in our family connections, and carrying us to the vicinity, they are drawn forth more particularly to such individuals as discover a likeness to ourselves in genius and disposition ; and appear to have interests co-incident with our own. The acquaintance thus begun, strengthens and improves by time ; and the pleasure and mutual benefits, resulting from it, prompt us to continue and enlarge it. These social circles increase with population, and at length occasion the establishment of societies, more effectually to secure those benefits, and render them permanent. But the social principle is of a nature so active and comprehensive, that it leads mankind to associate in larger bodies ; and to establish great communities, in which the strength and abilities of individuals being united and consolidated, each individual personally, as well as the community at large, may enjoy the security, and advantages resulting from that union.

Hence have originated government, and the various political connections, subservient and necessary to it. Hence, amidst a variety of others of different kinds, have sprung the numerous institutions for promoting philosophical knowledge, and investigating the works of nature : among which, some in *Europe*, and in particular, the Royal Academy of Sciences at *Paris*, and the Royal Society of *London*, bear a distinguished character.

Hence

Hence too, the societies of a similar nature, which begin to adorn *America*; particularly the Philosophical Society at *Philadelphia*, whose first essays, so ingeniously executed, are received by us as a pledge for still nobler productions. It is hoped they will excite in this new-formed society, a generous ardour and emulation in the same laudable pursuits; and that, as optic glasses, by collecting the solar rays, do assist and strengthen the corporeal sight, so the two societies, by centering in a proper focus the scattered rays of science, may aid and invigorate the intellectual: benefiting by their productions, not only the communities in which they are respectively instituted, but *America* and the world in general: both together resembling some copious river, whose branches, after refreshing the neighbouring region, unite their waters for the fertilizing a more extensive country.

The end and design of instituting this society are fully declared in the act of the legislature for its incorporation: namely, "to promote and encourage the knowledge of the antiquities of *America*, and of the natural history of the country; and to determine the uses, to which its various natural productions may be applied: to promote and encourage medical discoveries; mathematical disquisitions; philosophical enquiries and experiments; astronomical, meteorological, and geographical observations; improvements in agriculture, arts, manufactures and commerce; and, in fine, to cultivate every art and science, which may tend to advance the interest, honour, dignity and happiness of a free, independent, and virtuous people."

Here is opened a wide and extensive field, which the sons of literature are invited to cultivate and improve: a field of the richest soil, so varied in its qualities, as to be adapted to every mode

mode of cultivation. Here they will find abundant matter for the employment of their industry; and the most ample room for the exercise of their genius, in its utmost power of expansion.

Here they are directed to the fountain-heads of science, at which they are invited to recreate themselves; and of whose delicious waters they may drink without the danger of intoxication: or in case of danger, contrary to the effect of some other waters, it diminishes in proportion to the largeness of the draught: as intimated in the elegant lines of a well-known poet.

“ A little learning is a dangerous thing :
 Drink deep, or taste not the pierian spring.
 There shallow draughts intoxicate the brain ;
 And drinking largely sobers us again.”*

We shall now take a cursory view of some of the subjects, which are to employ the enquiries and researches of this society; and which we shall notice in the order observed in the act for incorporating it: making, in our progress, a few observations, that naturally result from them.

The antiquities of *America*, † are the first mentioned.—A knowledge in the antiquities of a country necessarily implies a knowledge of its antient history; and the researches into them lead directly to the source and original of things.

* *Pope's essay on criticism.*

† *Salve, magna parens frugum, Vespugia tellus,
 Magna virum: tibi res antiquæ laudis et artis
 Ingrediar, sanctos ausus recludere fontes.*

VIRG: GEORG: 2.

The *American Academy* is here personated; and the *res antiquæ laudis*, &c.—are to be considered as subjects of their future enquiry.

The compliment paid to our country by substituting *Vespugia* for *Saturnia*, it is hoped, will be as justly applicable to it as *Virgil's* was to *Italy*.

It is very pleasing and instructive—to recur back to the early ages of mankind, and trace the progressive state of nations and empires, from infancy to maturity, to old age, and dissolution:—to observe their origin, their growth and improvements, their different governments and laws, their variant customs and religion:—to observe the progress of the arts among them, which at first were few and rude, suggested by their wants and necessities, but gradually increasing in number and perfection, in proportion to the enlargement of the community, and as the culture of them was encouraged:—to observe the rise and gradual advancement of civilization, of science, of wealth, elegance, and politeness, until they had obtained the summit of their greatness:—to observe at this period the principle of mortality, produced by affluence and luxury, beginning to operate in them: manifesting itself with greater or less vigour in a variety of ways; and finally terminating in their dissolution, brought upon them by the vices attendant on luxury. Debilitated by these, and incapable of defending themselves against a vigorous invasion, their more hardy neighbours, invited by that circumstance, and perhaps irritated by the insolence, which national affluence and luxury inspire, invaded and subjugated them. In fine—to observe, after this catastrophe, a new face of things; new kingdoms and empires rising upon the ruins of the old; all of them to undergo like changes, and to suffer a similar dissolution.

Of these events ancient history exhibits the most convincing and instructive evidence: particularly the history of the four great empires, the *Assyrian*, the *Persian*, the *Macedonian*, and the *Roman*: which, like their founders, have long ago, suffered the fate incident to every thing human.

The

The knowledge of these events is so intimately connected with the knowledge of antiquities, that it is derived from the same source. Such too is the connection between ancient history and antiquities, and such the mutual assistance afforded to each other, that as, on the one hand, ancient history illustrates and explains antiquities, so, on the other, antiquities serve to verify and authenticate ancient history, or to correct its errors: and they sometimes give us a knowledge, or intimation of things, not recorded in history. Antiquities are also incidentally beneficial, by means of the political and other useful knowledge, resulting from the disquisitions necessary to explain them.

With respect to *America*,—there may be many things of *European* extraction, that come under the name and description of antiquities. So far as relate to general laws, customs and religion, they are, for the most part, homogeneous with what took place in the same age, and in the countries, from which the first *European* colonists emigrated; and it is probable they may be learnt, or explained, by the general or antiquarian history of those countries. These things, together with what was peculiar to those emigrants, and worthy of notice, if not already recorded in *American* history, will, with other remains of antient times, be proper subjects of our enquiry.

Whatever relates to the aboriginal natives of *America*, not already noticed in history, may be comprized in a very narrow compass. Their want of civilization, and improvement, and in particular their total want of literature, by which the small degree of knowledge they acquired by experience, might have been transmitted to succeeding generations, will justify the opinion, that the present race of them, in manners and conduct, differ very little from their ancestors, who lived centuries ago: excepting in some few particulars, occasioned by
their

their intercourse with foreigners. It may naturally be conjectured therefore, that the ancient and modern history of these people, with the exception of what might regard their wars, would appear but little more than a transcript of each other; and that it would be in vain to search among them for antiquities.

It is not improbable however, there may be many ancient historical records, and other valuable remains of antiquity, both *American* and *European*, in the possession of descendants from families, which first settled *America*; and of other persons upon this continent. It were to be wished, that gentlemen possessed, or knowing, of such remains, or of any kind of collections likely to contain such, would cause them to be examined; and if they tend to elucidate, enlarge, or correct history; or in any other way can be beneficial to the public, that they would have the goodness to communicate to this society some account of them: which, at the same time it will characterize them benefactors to the public, will entitle them to the thanks of the society.

The subject next mentioned in the act is natural history.—The society are to encourage the knowledge of the natural history of the country, and to determine the uses, to which its various natural productions may be applied.

Natural history is a copious subject, or rather it includes a very great variety of subjects. The several classes of animals, vegetables, minerals and fossils—in short, every thing produced by nature, whether in the earth, the sea, or air, inclusive of these, are within its department.

The knowledge of it is so necessary to the good of mankind, that it has been cultivated in its several branches, perhaps more than any other part of science; and in proportion to that cultivation,

vation, the properties and qualities of things, and their fitness for certain uses, have been discovered. This discovery has occasioned the application of them to those uses; and those have led to others, according as the wants, or the inventive faculties of man have directed. Hence we have derived the conveniences and ornaments of life, and every improvement in the arts of living.

At first however, at the origination of man, when it was indispensibly necessary he should be supplied with the means of subsistence, before he had acquired sufficient knowledge and ability to provide for himself, his beneficent CREATOR, the first and the supremely great Naturalist, made known to him the nature and qualities of things, and the uses to which they might be applied, so far as man's well-being required; and having provided for that, and endowed him with sufficient faculties, he was pleased to leave him and his posterity, to the exercise of those faculties, for the gaining a further degree in natural knowledge: in proportion to which, and to their improving it to the purposes, for which it was adapted, he intended their future accommodations should be. Accordingly, in different nations, from a greater or less exertion of equal faculties, or from a happier application of them, we find a greater or less degree of natural knowledge and improvements, and a proportionable difference in their respective conveniences and accommodations. Hence, with regard to these latter, the difference between *Europe* and *Africa*; between the most improved, and best accommodated, of mankind, and the Hottentots. But if their natural faculties are unequal, collectively taken, as probably is the case, the reason of that difference will strike us the more forcibly.

On

On the supposition of such inequality, it may in a great measure be accounted for, by the operation of natural causes: for altho' before the dispersion of mankind over the earth, which their increased numbers made necessary, the human faculties, by reason of a sameness in situation and other circumstances, might in general be equal, yet in process of time an inequality would probably take place from a change of climate.

Different climates differ greatly in their degrees of heat and cold, as well as in their natural productions. The tendency of immoderate heat is to relax, unbrace, and debilitate the human frame, and thereby diminish the powers of the mind as well as body, and indispose them to exercise and application: which indisposition, strengthened by the force of habit, at length becomes insurmountable.—On the other hand, immoderate cold too much contracts, and gives too great a degree of rigidity to, the fibres, and nervous system; and thereby making them less susceptible of quick and lively sensations, must proportionably affect the mind. Hence, in both cases, an inferiority of intellects. But in climates, duly tempered with heat and cold, where the organs of sense and motion are in due tone, it may be expected, if this theory be true, that mankind will be capable of greater exertions both of mind and body.*

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It

* The Baron de *Montesquieu*, in his *Spirit of Laws*, † where he treats, Of the difference of men in different climates, although he considers the effect of climate, more as it relates to the passions, than to the understanding, supposes not only that the difference is owing to different degrees of heat and cold; but that in proportion to them the body and mind are less or more vigorous.

If this be the case, what is said above respecting the effect of climates is not wholly just: for *there* it is supposed, that immoderate cold, as well as heat, diminishes the vigour of both.

The latter supposition may, in some measure, be supported by the history of the people living in the northern parts of *Norway*, *Sweden*, *Russia*, *Lapland*, and *Siberia*, whose characters, both as to mind and body, do not give us any exalted idea of the vigour or ability of either.

† Book xiv. chap. 2. *Nugent's* translation, the 2d. edit.

It will not from hence follow, that the exertions of different nations, dwelling in the same latitudes and climates, should be equal : for on the supposition of equality of capacity, there may be a variety of things, on which their exerting it may depend : such as education, religion, government, and other circumstances, or the appearance of some happy genius to instruct and direct them : and as these should happen to differ and influence them, their exertions would be proportionably different.

By way of illustration, * we may instance in what has taken place among ourselves ; and ask, whether the people of these United States, whose natural capacity, without doubt, equals that of *Europeans* in the same temperate climates, would in certain different circumstances, have opposed the unreasonable claims of *Britain* upon them ? Would they, if at all, have exerted themselves so vigorously against her enslaving domination, if they had not been educated in the principles of liberty ; if their religion, like that of some sects among them, had not allowed them to make use of carnal weapons in the defence of their liberty ; or if they had lived under a despotic government, and believed in the doctrine of passive obedience and non-resistance ? Or, lastly, if some among them, well situated to observe the course and tendency of *British* policy, had not alarmed them of their danger ?

If all or any of these circumstances had been different from, or contrary to, what have in fact taken place, the advantages derived from climate, in reference to natural capacity, had probably

* At the time of writing this discourse, the fleets and armies of *Britain* were, and long had been, invading us. This circumstance, together with the extraordinary manner, in which she conducted the war, occasioned in one or two of the political observations, adduced to illustrate the subject, some little poignancy of expression : which, it is apprehended, the occasion justified.

bly been lost ; and the world had not been astonished at the noble and unexpected exertions, we so happily made against the power of *Britain* : a power, distinguished for its magnitude, and with which we had to contend under the pressure of the greatest difficulties and discouragements.

One ardent wish will be indulged to me on this occasion, that we may ever deserve to be possessed of freedom and independence ; and by deserving them, convince our enemies, that the SUPREME ARBITER of the fate of nations will not suffer *Britain* to wrest them from us. The first of them—freedom—in a constitutional sense, while we remained connected with *Britain*, and until she spurned our repeated prayers to her for its restoration, was the only object of our exertions : and the latter—independence—wholly alien at that time from our inclinations, but now radicated in them, was the necessary effect of her obstinate injustice.

With respect to the Indian tribes of *America*, and the Blacks of *Africa*, if they descended from the same original stock, and are alike affected with the rest of mankind, they will partake of the advantages and disadvantages of climate in common with them : unless it be supposed, that the unexplored cause of the difference of colour may, in any measure, alter the effects of climate. If it doth not alter them, and if all nations in the same latitudes, considered in the gross, have equal capacities, the difference, that on comparison appears between them, must be casual ; arising from some certain adventitious circumstances, which take place in some of them, and not in others ; and which, as they arise, call those capacities into action, and thereby occasion that difference.

If

If by public encouragement, or by any other means, knowledge in general, and particularly natural knowledge, be supposed equal in any two or more nations, their different modes of applying it will produce very different effects ; which, taken together in each, may be equally valuable and useful : and if those effects come under the names of manufactures, they may be exchanged for each other to mutual benefit, even where the natural materials are the same in kind and quality : but where the materials differ in these respects, the greater must be the difference in those artificial productions, and the greater the benefit arising from the exchange.

The various productions, natural and artificial, of different countries, and the benefit resulting from a mutual exchange of them, give rise to commerce, navigation, and their attendants : in regard of which, the balance of advantage will always be in favour of that people, whose skill, industry, and cheapness of labour, enable them to manufacture and export, the greatest quantity of commodities : whether manufactured from the rough products of their own, or of other countries. And that balance, if the government of such a people be wisely administered, will give them a national superiority in riches, influence, and prosperity : which are principal objects with the honest and well-informed politician.

With respect to the natural productions of this country, they are perhaps as numerous as those of any other : but it doth not appear by any publications on the subject, that they have been examined to any great extent : so that our natural history is very imperfect, not only in relation to such productions as we have in common with other countries, but such as are peculiar to our own.

own. It is apprehended, however, that gentlemen of ingenuity and observation, have noticed and described many of them : and that their several descriptions and collections, brought into one stock, properly methodized and classed, would make a respectable figure ; and encourage further examinations and researches, in order to our obtaining an extensive, and well-digested body of *American* natural history. For a purpose so beneficial in itself, and so honorary to our country, it is hoped, such gentlemen will favour the Academy with their descriptions and collections ; and also with the result of their future researches, relative to the same subject.

These general observations, and particularly those concerning man, and the effects of climate, with the exception of some few of them incidentally made, come under the head, and are included in the idea, of natural history.

What has been said of the influence of climate, agrees in part with the doctrine of the celebrated *Montesquieu*.* So far as it differs from him, it may need apology : but it is submitted to your candour, just as it stood written before I had consulted him on that subject.

To these cursory observations on the subject of antiquities and natural history, I must here put an end, as I shall stand in need of the remains of your patience and candour, while I make a few observations of a different kind : which, though not necessarily connected with the subjects, that fall under the consideration of the Academy, will not be deemed impertinent, or unsuitable to this occasion.

The instituting of this society, and the necessity there was, that it should be preceded by such an institution as *Harvard's*, naturally

* See a foregoing marginal note.

naturally carry us back to the early times of this country, when *Harvard-College* was first founded. §

Our worthy ancestors, knowing from their own experience the advantages of a good education, very early, after their coming hither, provided the means of it for their children, and posterity ; and that excellent man, Mr. *Harvard*, made a large and generous bequest for that purpose : in consequence of which, the college was founded ; and in honour of him, and to perpetuate the remembrance of his generosity, his name was given to it. From that time to the present, it has been productive of the happiest effects ; and the influence and benefit of its instruction have been widely felt. Learning and the principles of good morals have been disseminated ; the arts and sciences cultivated ; and a spirit of freedom and enquiry promoted, and encouraged : in virtue of which, the best foundations have been laid for excellency in the learned professions.

All these have operated in so forcible and extensive a manner, that they have produced the other seminaries in *America*, established for the like noble purposes : so that our ALMA MATER may be justly considered as the remote parent of them all. I say, *our* ALMA MATER, not merely in relation to the members of this society, individually considered, most of whom, from her breasts, drew the nectareous milk of science, but in relation also to the complex body, the society itself : for, by her discipline, and unremitted inculcations, the way has been prepared for philosophical disquisitions, and an examen into the works of nature : without which, or some such preparatory discipline, this society could not have been formed : or being formed, could not have answered the end of its institution.

At

§ *Harvard-College* was founded in the year 1638 ; and the date of its first Charter was in 1642.

At the same time we are acknowledging our obligations to our ALMA MATER, justice demands the tribute of gratitude to her benefactors.

Foremost among these, stands the reverend *Harvard*; reverend by his profession, but much more so by real worth, and true dignity of character. By his generous bequest, and the spirit it inspired, the government was enabled to establish the college: which, by reason of the low state of the finances of the country, could not have been established without such assistance: so that he may justly be considered as the father and founder of the UNIVERSITY; and in that character his memory should be transmitted to posterity.

In the same catalogue also, the names of *Stoughton*, *Hollis*, *Holden*, *Hancock*, *Boylston* and *Hearsey*, whose vital part is disencumbered of its earthborn cottage, hold a distinguished place. Their noble and public-spirited benefactions, with those of other friends and encouragers of science, are at large recorded in the archives of the university; and therefore need not here be specifically enumerated.

Ye disembodied spirits, now "joined to the great majority," if ye are conscious of what is transacting in this place, and will deign to regard it, permit us to express our gratitude to you, arising from a sense of the benefits already derived, and which are deriving, to individuals and the public, from your institutions and benefactions.

If divinity and morality—if the knowledge of the Hebrew scriptures, and of the oriental and other languages—if mathematics, and natural, and experimental philosophy—if the medical art, the belles lettres, and literature in general—are beneficial to mankind, ye have not lived in vain: since, to promote the know-
ledge

ledge of these has been the object of your aim in those institutions ; and your aim has been crowned with the most happy and extensive success. This has insured to you, at least in this country, universal approbation ; and your names will be remembered with honour, so long as literature shall be esteemed, or any vestige of it remain here.

Though wrapt in the shroud of death be your mortal part, ye still live, and through successive generations may ye continue to live, in the grateful breasts of your lettered sons.—Consecrated to fame, and born on its strongest pinions, may your memory reach to the remotest ages, expanding as it flies. And when ages cease to roll—when all things shall be ingulphed in vast eternity—when eternity itself shall be absorpt in the self-existence of the DEITY, may ye be blessed, as we humbly trust ye now are, supremely blessed, with the approbation of HIM, who gave you the means, and the will to do good. In fine, may your virtues, and excellent example, by inspiring imitation, procure such benefactions to *Harvard-College*, as to make it, in the most proper and extensive sense, an *University*.

With respect to its surviving benefactors, I shall not attempt to name or characterize them, as the doing it might offend their delicacy, or favour of adulation : they will however have the pleasing satisfaction to reflect, that the eulogium on the similar virtues of others, is an eulogium on their own : and a consciousness of merit will compel them, without hazarding the charge of a vain-glorious appropriation, to apply it to themselves.

To have said thus much on the subject of the college, will not, on this occasion, be deemed impertinent, as the instituting of it was, not merely consistent with the forming such a society as ours, but necessary to precede it ; and as the old institution
may

may with propriety be reputed the genuine parent of the new one. Such is the connection between them, and such the dependence of this upon the other, that as most of its present members are sons of HARVARD, so its future vernacular members will probably, for the most part, be supplied from the same stock: at least so long as HARVARD's sons shall continue to be distinguished for scientific accomplishments: which, it is fervently hoped, will be as long as science, or any trait of it, remains in the world: or as long as nature, the great subject of it, endures.

Derived from such a parentage, and animated by the noble example of other philosophical institutions, may this society contribute its full share to the common stock of knowledge; and endeavour, by the most generous exertions, to answer the valuable purposes of its institution.

“Rapt into future times,” and anticipating the history of our country, methinks I read in the admired pages of some *American Livy*, or *Thucydides*, to the following effect.

A century is now elapsed since the commencement of *American* independency. What led to it, and the remarkable events of the war, which preceded and followed it, have been already related in the course of this history.

It was not to be expected, that our ancestors, involved as they were in a civil war, could give any attention to literature and the sciences: but superior to their distresses, and animated by the generous principles, which liberty and independency inspire, they instituted the excellent society, called *The American Academy of Arts and Sciences*.

This society formed itself on the plan of the philosophical societies in *Europe*, adopting such rules, and principles of conduct.

duct, as were best suited to answer the end of its institution. Among others, they laid it down as a fundamental principle, that as true physics must be founded on experiments, so all their enquiries should, as far as possible, be carried on, and directed by them. This method was strongly recommended by Sir *Francis Bacon*, "a genius born to embrace the whole compass of science, and justly stiled, the first great reformer of philosophy,"* It was adopted by succeeding philosophers, and particularly by the immortal *Newton*, whose system of philosophy, founded on the laws of nature, will for that reason be as durable as nature itself.

Taking these great characters for their guide, and influenced by their illustrious example, they proceeded on fact and observation, and did not admit of any reasonings or deductions, but such as clearly resulted from them. This has been the uniform practice of the society : whose members, from time to time, having been chosen from men of every country, from every class and profession, without any other distinction than was dictated by the dignity of their characters, by their morality, good sense, and professional abilities, we find in the printed transactions of the society, the best compositions on every subject, within the line of their department. We find in those transactions new facts, new observations and discoveries ; or old ones placed in a new light, and new deductions made from them.

They have particularly attended to such subjects as respected the growth, population, and improvement of their country : in which they have so happily succeeded, that we now see agriculture, manufactures, navigation and commerce, in a high degree of

* *Mallet's life of Lord Chancellor Bacon.*

of cultivation ; and all of them making swift advances in improvement, as population increases. In short, they have, agreeably to the declared end of their institution, “ cultivated every art and science, which might tend to advance the interest and honour of their country, the dignity and happiness of a free, independent, and virtuous people.”

This is demonstrably evident from the numerous volumes the society have published of their transactions. These volumes are a noble collection of useful knowledge ; and considered together in their miscellaneous state, strike the mind with a splendour, resembling the galaxy in the heavens, derived from the combined light of countless myriads of constellations : and like that too, when the several corresponding parts are viewed in their proper connections, they appear to be parts of a whole ; and to constitute the most useful systems : systems distinguished by their beauty, regularity, and proportion.—Thus far our historian.

May this prophetic history be realized by fact, and may the transactions of this society justify the future historian, in giving it a character, like the one just delineated : or rather, a character deservedly more exalted.

In the mean time, as the society is formed on the most liberal principles, and is of no sect or party in philosophy, it wide extends its arms to embrace the sons of science of every denomination, and wheresoever found ; and with the warmth of fraternal affection invites them to a philosophical correspondence : and they may be assured, their communications will be esteemed a favour, and duely acknowledged by the society.

I shall close this discourse with a short reflection, resulting from one of the subjects we have been considering.

When :

When we contemplate the works of nature, animate and inanimate, connected with our earth ; observe the immense number and variety of them ; their exquisite beauty and contrivance ; and the uses to which they are adapted :—when we raise our view to the heavens, and behold the beauteous and astonishing scenes they present to us—unnumbered worlds revolving in the immeasurable expanse ; systems beyond systems composing one boundless universe : and all of them, if we may argue from analogy, peopled with an endless variety of inhabitants :—When we contemplate these works of nature, which no human eloquence can adequately describe, they force upon us the idea of a SUPREME MIND, the consummately perfect author of them,—

“ *That* universal spirit, which informs,

“ Pervades, and actuates the wond’rous whole.”

In compare with whom his works, great and stupendous as they are, are “ nothing, less than nothing, and vanity.” But—though annihilated by the comparison, yet—viewed in themselves, they powerfully persuade us to exclaim, in the rapturous and sublime language of inspiration, “ Great and marvellous are thy works, LORD GOD almighty, in wisdom hast thou made them all.”



PHILOSOPHICAL
MEMOIRS.

PART I.

ASTRONOMICAL AND MATHEMATICAL
PAPERS.

I. *A Method of finding the Altitude and Longitude of the non-agesimal Degree of the Ecliptic ; with an Appendix, containing Calculations from corresponding Astronomical Observations, for determining the Difference of Meridians between Harvard-Hall, in the University of Cambridge, in the Commonwealth of Massachusetts, and the Royal Observatories at Greenwich and Paris. In a Letter from the Reverend JOSEPH WILLARD, President of the University, and Corresponding Secretary of the American Academy of Arts and Sciences, to the Honorable JAMES BOWDOIN, L. L. D. President of the Academy.*

S I R,

AS the parallaxes of the planets in latitude and longitude come frequently into use, in astronomical calculations, and particularly in deducing the difference of meridians between one place and another, from corresponding observations
of

of solar eclipses and occultations of fixed stars by the moon, every method which can be discovered, to shorten the work, or make it more easy, must be of utility. In calculating these parallaxes, it is necessary to find the altitude and longitude of the nonagesimal degree of the ecliptic. As I have given some attention to this subject, I take the liberty, Sir, of enclosing to you a paper, containing a method of finding these prerequisites, different from any that I have happened to meet with, and (to me indeed) taking the whole process together, easier, if not shorter. It is deduced from a projection which must make the method very obvious, to those acquainted with the sphere and with spheric trigonometry. You will find an appendix upon the longitude of *Cambridge*. If you think proper to communicate the whole to the Academy, you have my consent.

I am,

with the greatest respect, &c.

Cambridge, August 4, 1783.

DEFINITIONS.

1. THE right ascension of the mid-heaven is that point of the equator, which culminates, or is in the meridian of any particular place, at a given time, and is found by adding the given apparent time, reckoned astronomically, to the sun's right ascension, calculated for the same time. Or, it may be found, by reducing the given apparent time to mean time, and adding it to the sun's mean longitude. But, if the hours are reckoned according to civil time, we must take the difference between the

the apparent given time and noon ; and if it is the forenoon, this difference must be subtracted from the sun's right ascension ; but if it is the afternoon, it must be added. If the mean longitude is taken, the mean time must be used.

2. The nonagesimal degree of the ecliptic is its highest point above the horizon, and is 90° distant from each point of the ecliptic, where intersected by the horizon. This nonagesimal point is determined by a perpendicular to the ecliptic, which passes through its poles and the poles of the horizon, the altitude of which point is measured from the horizon, upon this perpendicular.

PROBLEM.

Given the latitude of a place, the obliquity of the ecliptic, the time of the day, the sun's true longitude, his right ascension, and consequently the right ascension of the mid-heaven, to find the longitude and altitude of the nonagesimal degree of the ecliptic.

A GENERAL SOLUTION OF THE FOREGOING PROBLEM.

In plate I. fig. I. let the circle $\infty p \infty L$ represent the solstitial colures ; then, the poles of the equator and of the ecliptic will be in the plane of this circle. Let the diameter $E \Delta Q$ represent a portion of the equator ; $\infty \Delta \infty$ a portion of the ecliptic ; P, the north pole of the equator ; p , the north pole of the ecliptic ; S and L their south poles. Let the arc Pc S mark the right ascension of the mid-heaven, from the nearest equinoctial point ; then this arc will represent the meridian of some place, at a given time, and c and w will be the culminat-
ing

ing points of the equator and ecliptic. Let the arc bZi represent the latitude of some given place ; then the point Z , where the arc is intersected by the meridian, is the zenith of the place, at the given time, and is one of the poles of the horizon ; the arc HOR is the horizon ; the line ZN its axis, and the point N of the axis, where it is intersected by the arc PcS continued, is the other pole of the horizon, or the nadir. The arc pZL , drawn through the poles of the ecliptic and of the horizon, marks out the longitude of the nonagesimal degree upon the ecliptic at U , the altitude of which, or height above the horizon is VU . Now the arc pZL is perpendicular both to the horizon and the ecliptic, as it passes through the poles of each, and as pU is $= ZV = 90^\circ$ and ZU is common to both, take ZU from each, and there will remain $pZ = VU$ the altitude of the nonagesimal degree of the ecliptic. The longitude and altitude of this point, therefore, may be readily found by the spheric triangle PpZ , in which are given two sides and the included angle, viz. side $PZ =$ the co-latitude of the given place ; the side $Pp =$ the distance of the poles of the equator and ecliptic $=$ the obliquity of the ecliptic ; and the angle pPZ , the value of which may always be determined by the following general rules, which, from diagrams, will appear very obvious.

The right ascension of the mid-heaven being between 270° and 360° or 0° , and between 0° and 90° , the nearest equinoctial point is γ ; and in the first case, angle pPZ is acute, and is found by subtracting 270° from the right ascension of the mid-heaven. In the second case, the angle is obtuse, and is found by subtracting 270° from the right ascension of the mid-

mid-heaven added to 360° , or, which is the same thing, by adding the right-ascension of the mid-heaven to 90° .

The right ascension of the mid-heaven being between 90° and 180° , and between 180° and 270° , the nearest equinoctial point is α ; and in the first case, angle pPZ is obtuse, in the second acute, and in each case the angle is found, by subtracting the right-ascension of the mid-heaven from 270° . These rules are to be used when the latitude of the given place is north; but when it is south, they must be inverted to find the corresponding angles, as will appear evident by a diagram.

From Z , let fall the perpendicular Zx upon the primitive circle: And to know whether the perpendicular, in any case, will fall upon the side of P next to p , or opposite to it, the following rules may be observed.

When the right ascension of the mid-heaven is between 180° and 270° , or between 270° and 0° , that is, when angle pPZ is acute, the perpendicular will fall upon the side of P next to p ; but when the right ascension of the mid-heaven is between 0° and 90° , or between 90° and 180° , that is, when angle pPZ is obtuse, the perpendicular will fall upon the side of P opposite to p .

For the side pZ , the altitude of the nonagesimal degree. Radius : Sine co-angle pPZ :: Tangent side PZ : Tangent side Rx . Then, if the perpendicular be on the side of P next to p , the difference between Pp and Px will be px ; but if it fall on the side of P opposite to p , the sum of Pp and Px will

will be px . px being found say, Sine co- Px : Sine co- px
 $::$ Sine co- PZ : Sine co- pZ .

For angle PpZ , or $\angle$ at the pole of the ecliptic, Sine segment px : Sine side Px $::$ Tangent angle pPZ : Tangent angle PpZ .

When the perpendicular Zx falls upon the side of P opposite to p , or between P and p , the angle PpZ is acute ; but when it falls beyond p , it is obtuse.

By the angle PpZ , the longitude of the nonagesimal degree is determined thus :—When the nearest equinoctial point is γ , subtract this angle from ϖ or 3° , adding 12° to 3° , when necessary ; the remainder will be the longitude of the nonagesimal degree. If the nearest equinoctial point is α , add this angle to ϖ or 3° , and the sum will be the longitude of the nonagesimal degree.

Let the foregoing general rules be now elucidated by a particular

E X A M P L E.

Required the longitude and altitude of the nonagesimal degree of the ecliptic, at the royal observatory at Greenwich, August 5, 1766, at $5^h 29' 57''$ P. M. apparent time ?

The solar and lunar elements from MAYER's tables.

At $5^h 29' 57''$ P. M.

The sun's longitude

$4^\circ 13' 9'' 51''$

The obliquity of the ecliptic

$23^\circ 28' 18''$

The

MATHEMATICAL PAPERS. 7

The latitude of Greenwich	51° 28' 39"
Reduced to the center, the earth being } an oblate spheroid	51 14 11
Complement = PZ	38 45 49

For the sun's right ascension.

Radius	10
: Sine of the co-obliquity of the } ecliptic,	66° 31' 42" 9 9624911
:: Tang: ☉'s longitude from near- } est equinoct point,	46 50 9 10 0278498
: Tang: ☉'s right ascension from } nearest point, viz. ♈	44 21 46 9 9903409
Subtract the above from	180 0 0
The remainder is ☉'s right asc. from ♈	135 38 14

The given time 5^h 29' 57" being reduced to degrees, at the rate of 15° per hour, gives 82° 29' 15". Add this to the sun's right ascension 135° 38' 14"; the sum 218° 7' 29" is the right ascension of the mid-heaven. This subtracted from 270° according to the rule, leaves 51° 52' 31" for angle pPz.

For side pZ, the altitude of the nonagesimal degree.

Radius	
: Sine Co ∠pPZ	38° 7' 29" 9 7905493
:: Tangent PZ	38 45 49 9 9047023
: Tangent Px	26 22 10 9 6952516
Subtract Pp	23 28 18
Remains px	2 53 52

Sine

Sine Co	Px	63° 37' 50"	9 9522832
: Sine Co	px	87 6 8	9 9994443
:: Sine Co	PZ	51 14 11	9 8919475
: Sine Co	pZ	60 21 48	9 9391086
Alt. nona. deg.	pZ	29 38 12	

For angle Ppz

Sine	px	2° 53' 52"	8 7037573
: Sine	Px	26 22 10	9 6475369
:: Tangent	∠pPZ	51 52 31	10 1052425
: Tangent	∠PpZ	84 53 49	11 0490221
Obtuse =		95 6 11	

To =	3° 0' 0"
Add ∠PpZ =	3 5 6 11

The sum is = the } 6 5 6 11
 long. of nona. deg. }

By the foregoing process it appears, that the longitude of the nonagesimal degree is 6° 5' 6" 11", and the altitude 29° 38' 12".

APPENDIX.

MATHEMATICAL PAPERS.

APPENDIX.

THE ascertaining of the difference of longitude between various places on the globe, particularly between important headlands and seaports, and also between places where astronomic observations are made, to perfect the knowledge of the heavens, and to improve navigation and geography, are very desirable objects. Observations of eclipses of the moon and of Jupiter's satellites have frequently been made use of for this purpose. When the beginning or ending has been observed in two places, the difference in time is the difference of meridians, which may be reduced to degrees, at the rate of 15° per hour. But the earth's shadow is so imperfectly defined at the moon, that the beginning or ending of a lunar eclipse cannot be so satisfactorily determined, that the difference of meridians, deduced from these observations, can be entirely depended upon. The beginning or ending of the eclipses of Jupiter's satellites can be determined with more precision ; but still, much depends upon the magnifying powers and the aperture of the telescopes, which are made use of for the observation : nor is the difference of meridians between two places, deduced from these observations, reckoned accurate, unless there is a considerable number, both of immersions and emersions, to be compared with corresponding ones. Of late years, therefore, observations of solar eclipses, of occultations of fixed stars by the moon, and of transits of the inferior planets over the sun's disk, when made under favourable circumstances, have been most sought for, and used, when they could be obtained, for determining differences of meridians. In these observations, the difference of times is not the difference of me-

B

ridians,

ridians, but is sometimes more, and sometimes less, according to the parallaxes. These, therefore, must be carefully computed; and the tediousness of the process has, doubtless, prevented observations of this kind from becoming so generally useful, as they would otherwise have been. But, as the difficulty may appear lessened, by having the whole operation brought into one view, I now take the liberty of doing it, for the sake of those who have not made great advances in astronomy, should any such meet with this paper. I have taken, for examples, those observations which have led to a determination of the difference of meridians between London and Cambridge, and Paris and Cambridge. An accurate determination of this difference may be very useful. Hereby, the astronomic tables, which have been fitted to the meridians of the celebrated observatories of Paris and Greenwich, are made our own, for all the purposes of calculation; and our observations may be made use of, for correcting and improving those tables: And should new ones be constructed for Cambridge, the same may be accommodated to the European observatories.

P R O B L E M.

Given the moon's longitude, latitude, horizontal parallax and horizontal semi-diameter, together with the altitude of the nonagesimal degree of the ecliptic, and the angle of it's pole, or angle PpZ , and consequently the longitude of the nonagesimal degree, to find her parallax in latitude and longitude, her visible semi-diameter, or semi-diameter augmented agreeably to her altitude or zenith distance, and the visible difference of longitude between the sun and moon?

If

If the process be trigonometrical we must first find the moon's altitude and parallax angle.

In plate I, figure I, let the arc peL cut the ecliptic in $e =$ the moon's longitude, and let the arc lat mark out her latitude; then the point of intersection of the two arcs at p , will be the moon's true place or position. Let the vertical arc ZpN be drawn; then, in the triangle pZ , the side Zp will be the moon's zenith distance, or co-altitude, and the angle pZ her parallax angle; to find which, there are given two sides and the included angle, viz. the side $pZ =$ the altitude of the nonagesimal degree; the side $pd =$ the moon's distance from p one of the poles of the ecliptic $=$ the complement of her latitude, and the angle $Zpd =$ the difference between the moon's longitude and the longitude, of the nonagesimal degree.

From Z let fall the perpendicular Zd , dividing the oblique angled triangle pZ into two right-angled triangles, right-angled at d .

For side Zp the moon's zenith distance.

Radius : Sine Co-angle $Zpd ::$ Tangent $pZ : \text{Tangent } pd$.
Take pd from p and the remainder will be pd ; then say
Sine Co- $pd : \text{Sine Co-}pd :: \text{Sine Co-}pZ : \text{Sine Co-}Zp$.

For angle pZ , the moon's parallax angle.

Sine $pd : \text{Sine } pd :: \text{Tangent angle } Zpd : \text{Tangent angle } pZ$.

We must next find the moon's parallax in altitude, preparatory to which, let the moon's distance from the earth in semi-diameters of the earth be found.

In plate I, figure II, in the plain right-angled triangle BAC , right-angled at B , let CB be the semi-diameter of the earth, which call r , the angle BAC the moon's horizontal parallax, the hypotenuse CA the moon's distance from the earth's center in semi-diameters of the earth, to find which say Sine angle BAC : side BC :: Radius : hypotenuse CA .

Having found the moon's distance from the earth's center, there are given in plate I, figure III, in the plain oblique-angled triangle BAC , the side AC = the moon's distance from the earth's center, the side BC = the earth's semi-diameter, and the included angle BCA = the moon's true zenith distance, to obtain angle BAC = the difference between angle BCA the true zenith distance and DBA the visible zenith distance = the moon's parallax in altitude ; to find which, subtract angle BCA from 180° the sum of the three angles, the remainder will be the sum of the two unknown angles ABC and BAC : Take the sum and difference of the sides AC and BC ; then say, the sum of the two sides AC and BC : their difference :: the Tangent of half the sum of the two unknown angles : the Tangent of half their difference. Subtract the half difference from the half sum, and the remainder will be the lesser angle BAC = the moon's parallax in altitude,* which
added

* The common method of deducing the moon's parallax in altitude from her true zenith distance is by approximation ; finding the parallax for the true zenith distance as if it were the visible, by adding together the logarithmic Sine of the zenith distance and of the horizontal parallax : then adding the parallax thus found to the true zenith distance, and considering the sum as the visible zenith distance, and then going over the work again ; but I have exhibited the above method as the direct one ; and it is but little longer than the other.

added to the true zenith distance, will give the visible = angle DBA.

For the parallax in latitude and longitude.

Having found the moon's parallax in altitude suppose it set off plate I, figure I, upon the vertical arc from $\mathfrak{D}$ to m towards the horizon, because the visible zenith distance is greater than the true; then, the point m will be the moon's visible place, or her place as seen from some given spot on the earth's surface. From p to L , through m , let the arc $p mL$ be drawn; then, in the triangle $pm\mathfrak{D}$, the angle $mp\mathfrak{D}$ = the distance between n and e on the ecliptic is the moon's parallax in longitude; and the segment my , of the side pm , is her parallax in latitude; to find which by spheric trigonometry, there are given two sides and the included angle, viz. side $p\mathfrak{D}$, the moon's distance from the pole of the ecliptic; the side $\mathfrak{D}m$, the moon's parallax in altitude, and angle $p\mathfrak{D}m$ = the supplement of angle $p\mathfrak{D}Z$ to 180° . Or it may be more convenient to take the triangle $L\mathfrak{D}m$; in which are given sides $L\mathfrak{D}$ and $\mathfrak{D}m$ and the included angle $L\mathfrak{D}m$, = $p\mathfrak{D}Z$ to obtain the same things. But the moon's parallax in latitude and longitude may be found more easily, by the following method.—Let fall the perpendicular mr upon the arc $p\mathfrak{D}L$; then, there will be formed a right-angled triangle $\mathfrak{D}mr$, right-angled at r . As the perpendicular mr , in eclipses of the sun, and even in occultations of fixed stars by the moon, will always be near the ecliptic, it may be considered as parallel to it, without any sensible error; consequently, the side mr may be reckoned = the segment ym . We may therefore call the side $\mathfrak{D}r$ the moon's parallax in latitude, and the side mr , augmented in the ratio of the Sine of the moon's visible co-latitude to radius,

dus, will be equal to ne , the parallax in longitude. In occultations, when the moon's latitude is considerable, this augmentation must take place ; but in solar eclipses, her latitude is always so small, that the difference between mr and ne is imperceptible ; therefore, mr may be considered as the true parallax in longitude.

As the sides of the triangle Δmr are very short, it may be reckoned a plain one, without any perceptible error ; and the sides Δr and mr may be found by plain right-angled trigonometry, the hypotenuse Δm , and the angle $m\Delta r = \text{angle } p\Delta Z$, being given.

For side Δr , the moon's parallax in latitude.

Radius : Δm in seconds :: Sine co-angle $m\Delta r$: side Δr in seconds.

For side mr , the parallax in longitude.

Radius : Δm in seconds :: Sine angle $m\Delta r$: side mr in seconds.

GENERAL RULES FOR APPLYING THE PARALLAXES.

In a place in north latitude, when the moon's latitude is north, if the parallax in latitude is less than the true latitude of the moon, subtract it from her latitude ; the remainder will be her visible latitude north. If the parallax be the greater, subtract her latitude therefrom ; the remainder will be the moon's visible latitude south. If the true latitude of the moon be south, the parallax in latitude, whether greater or less, must be added, and the visible latitude will be south. These rules must be inverted, when the latitude of a place is south.

The

The parallax in longitude must be added to the moon's true longitude, to give the visible, when her true longitude is to the east of the nonagesimal degree, otherwise, it is to be subtracted.

If the moon's true latitude and longitude are to be found from the visible, the above rules, for applying the parallaxes, must be inverted.

For the moon's augmented or visible semi-diameter according to her altitude or zenith distance.

The visible diameter of the moon, to a spectator on the surface of the earth, is continually enlarging, from the horizon to the zenith; because the semi-diameter of the earth bears a sensible proportion to the moon's distance. When the moon is in the zenith of an observer on the earth's surface, she is nearer to him by almost a whole semi-diameter of the earth, than when she is in his horizon. In the horizon, therefore, the moon's visible diameter must be the least, and in the zenith the greatest of all.

The visible diameter of any planet is inversely as it's distance from us; therefore, to find the moon's augmented semi-diameter, from her horizontal, at a particular zenith distance, we must say,—The moon's distance from the earth's surface at the given visible zenith distance : her horizontal distance, or distance from the earth's center† :: her horizontal semi-diameter : her augmented or visible semi-diameter at the given zenith distance. But sides of plain triangles are measured by the sines of
of

† The moon's distance from a spectator at the earth's center, is the same, at every altitude, as her horizontal distance.

of the opposite angles ; thus in plate I, figure III, sine angle BCA, the moon's true zenith distance, measures the side AB, the moon's distance from a spectator on the earth's surface ; and sine angle ABC, or which is the same, sine angle DBA, the moon's visible zenith distance measures the side AC, the moon's distance from the earth's center = her horizontal distance. We may therefore say, Sine angle ACB, the moon's true zenith distance : sine angle DBA, her visible zenith distance :: her horizontal semi-diameter : her augmented or visible semi-diameter.*

For the visible difference of longitude between the center of the sun and moon.

To obtain this, there are given the sum of the sun's horizontal semi-diameter, and the moon's augmented or visible semi-diameter, at the time of the observed beginning or ending of the eclipse, for which the calculation is made, and the visible latitude of the moon from the sun, found by properly applying the parallax of latitude from the sun, by which a plain right-angled triangle may be formed. Thus in the plain right-angled triangle $\odot E D$, plate I, figure IV, there will be given the hypotenuse $\odot D$ = the sum of the semi-diameter of the sun or moon,† or visible distance of their center, and the side $E D$, the

* The augmentation of the moon's semi-diameter to her altitude or zenith distance may be found in some astronomical tables ; but I thought it best to give the trigonometrical process.

† This sum of the semi-diameter ought to be diminished, on account of diffraction, or the inflection of the rays which pass the limbs of the moon, supposed to be caused by her atmosphere. When an eclipse or occultation would appear to us to be just begun, were there no inflexion, this causes her limb to be visibly distant from

the visible difference of latitude between their centers, to find the side $\odot E$, their visible difference of longitude.* This may be obtained by Euclide, Book I, Prop. 47; or it may be found by common trigonometry thus $\odot D : \text{Radius} :: ED : \text{fine angle } E\odot D$; then $\text{Radius} : \odot D :: \text{fine co-angle } E\odot D = \text{angle } ED\odot : \odot E$. But $\odot E$ may be obtained more expeditiously, thus; find the logarithms for the sum and difference of $\odot D$ and ED ; the half sum of these logarithms is the logarithm of $\odot E$.

Having found, for the place from whence we design to reckon the difference of meridians, the parallaxes, and the visible difference of longitude between the centers of the sun and moon, at the observed time of the beginning or ending of a solar eclipse, or occultation of a fixed star, or for both the beginning and ending, where both have been observed, we must assume the difference of meridians in time, between the first

C — place,

from the limb of the sun, or from the fixed star $4\frac{1}{2}''$: Therefore, at the instant when the beginning or end appears to us, it is obvious, that the centers cannot be so far asunder by $4\frac{1}{2}''$, as the sum of the semi-diameters; and by so much must this sum be diminished. For a brief account of this inflection, see *ASTRONOMIE* par M. DE LA LANDE, tome ii. art. 1992, 1993, edition seconde.

* As the sun has a visible latitude, equal to his parallax in latitude, the side $\odot E$ is not a portion of the ecliptic, but is parallel to it: But as it's utmost distance from it can never be more than between $8''$ and $9''$, the difference between this side and the visible difference of longitude, is imperceptible. In an occultation, when the star's latitude is large, this side, parallel to the ecliptic, must be enlarged, to give the visible difference of longitude between the star and the moon's center, in the ratio of the cosine of the moon's visible latitude, or of the star's latitude to Radius, according as the one or the other is nearest to the ecliptic.

place, and that whose longitude is sought ; and must find the parallaxes the augmented semi-diameter of the moon and the difference of longitude between the centers of the sun and moon, or star and moon, for the observed time of the beginning or ending of the eclipse, or occultation, at this second place.

We are next to find the time of the true ecliptic conjunction of the moon and sun, or moon and star, according to observation : And here we are to observe, that at the beginning of an eclipse or occultation, the moon is visibly not so far advanced in longitude, as the sun or star, therefore, if we subtract the visible difference of longitude from the sun's visible longitude,* or from the star's true longitude,† we shall have the visible longitude of the moon. If to this visible longitude, we apply her parallax in longitude, with it's proper sign, we shall have her true longitude according to observation, the sun's or star's longitude being supposed to be accurately given by the tables. If we make use of the moon's parallax in longitude from the sun instead of her simple parallax, which will prevent a separate calculation for the sun's parallax in longitude, the visible difference of longitude being subtracted from, or added to the sun's true longitude will give the moon's visible longitude nearly ; and her parallax in longitude from the sun properly applied to this will give her true longitude.

The

* The sun's visible longitude is found by applying his parallax in longitude with the proper sign to his true longitude.

† As the fixed stars have no perceptible parallax, there can be no distinction in calculations between the visible and true longitude.

The difference between the sun's or star's longitude and the moon's thus found will, it is obvious, be the true difference of longitude between them. But this may be found more readily thus—In eclipses, if the visible difference of longitude and the moon's parallax in longitude from the sun, and in occultations, the moon's simple parallax, be both additive or both subtractive, their sum is the true difference of longitude, between the moon and sun or star. If the one is additive, and the other subtractive, their difference is the difference of longitude.

It sometimes, though rarely, happens, that the moon, at the beginning of an eclipse or occultation, has past the true conjunction,* although her visible longitude is less; this is the case when the parallax, being additive, is greater than the difference of longitude between the moon and sun or star. We must invert this rule, to know whether the moon has past the true conjunction, at the end.

The true difference of longitude between the moon and sun, or moon and star being found, both for the beginning and ending of a solar eclipse, or of an occultation, where both have been determined by observation, the sum of these, when the moon was on different sides of the point of the true ecliptic conjunction, at the beginning and ending or the difference, when she was upon the same side in both, will be her whole motion in longitude from the sun or star during the time of the

C 2

eclipse

* We shall find an instance of this at the beginning of the solar eclipse at Greenwich, June 24, 1778.

eclipse or occultation, according to observation.* Then we must say, This whole motion : the whole time of the duration :: the difference of longitude at the beginning or ending : the distance in time between the observed beginning or ending and the true ecliptic conjunction.

When the beginning or ending only has been observed, at the places for which we made the calculations, we must use the moon's horary motion from the sun, as given by the tables, for the first term, and one hour or $3600''$, for the second term.

The time thus found is to be added to the observed time of the beginning of the eclipse or occultation, when the moon is behind the true conjunction ; but if she has passed it, then it must be subtracted ; and the sum or difference will be the time of the true ecliptic conjunction according to observation.

This

* If this whole motion is considerably different from that given by the tables, and we make dependance upon the observations of the beginning and end of the eclipse or occultation, we are to conclude, that the moon's latitude, by the tables, is not exact ; and the correct latitude must be sought, for the beginning and end. These being obtained, the visible difference of longitude between the sun's and moon's center is to be found, conformably thereto. By this it is supposed, that the moon's horary motion, by the tables, is true ; which may be concluded to be generally the case, in eclipses and occultations ; and indeed it is much more likely that the latitude should be given too small or too large, in the tables, than that the horary motion should be considerably erroneous by them. In more than five hundred longitudes of the moon, calculated from Mayer's printed tables, by M. Lemery, which he compared with corresponding longitudes, deduced from the lunar observations of the late accurate and celebrated Dr. Bradley ; which comparisons are published in *Connoissance des Temps pour l' Année, 1783*, I find that the error in the moon's horary motion in longitude rarely amounts to $2''$. It is not common for it to exceed $1''$; and it is generally but a few tenths of a second. We may therefore make great dependance upon the horary motion given by these tables.

This rule is to be inverted, to find the time of conjunction from the observation of the end of the eclipse or occultation.

The time of the true ecliptic conjunction, according to the observations, being found in this manner, for each place, the difference of times will be the difference of meridians.

Let the preceding rules be now exemplified.

The beginning of a solar eclipse was observed at the Royal Observatory at Greenwich, by Dr. Mashehlyne, the Astronomer Royal, August 5, 1766, at $5^{\text{h}} 29' 56''$ P. M. apparent time, and by his assistant at $5^{\text{h}} 29' 58''$ P. M. the mean being $5^{\text{h}} 29' 57''$. The end was observed by the Doctor at $7^{\text{h}} 11' 27''$, and by his assistant at $7^{\text{h}} 11' 40''$ P. M. the mean being $7^{\text{h}} 11' 33''$.

The same eclipse was observed by the late Dr. Winthorp, Hollis Professor of the Mathematics and Natural Philosophy, at Cambridge, who made the beginning at $11^{\text{h}} 39' 23''$ A. M. and the end at $2^{\text{h}} 45' 9''$ P. M. apparent time.

Required the difference of meridians between Greenwich and Cambridge, by these corresponding observations?

The solar and lunar elements for calculating the parallaxes, &c. are from Mayer's tables.

For Greenwich at $5^{\text{h}} 29' 57''$.

The sun's longitude, $4^{\circ} 13' 9'' 51'' 0$

The moon's ecliptic longitude, $4^{\circ} 13' 3'' 59'' 0$

The

The moon's latitude north decreasing,	° 33' 17" 0
The sun's horary motion,	2 43 2
The moon's horary motion in longitude in the ecliptic,	29 29 5
The moon's horary motion in latitude,	2 43 2
The moon's horizontal parallax for Greenwich,	53 58 4
The sun's horizontal parallax,	8 4
The moon's horizontal parallax from the sun,	53 50 0
The sun's horizontal semi-diameter by observation,	15 47 0
The moon's horizontal semi-diameter,	14 44 5
The obliquity of the ecliptic,	23 28 18 0
The latitude of Greenwich Observatory,	51 28 39
Reduced to the center,	51 14 11
Complement = PZ	38 45 49

From these elements the altitude of the nonagesimal degree has already been found,

And it's longitude,

From which subtract the moon's longitude,

The difference is equal to angle ZpD ,

= 52 2 12

For the moon's zenith distance and parallactic angle. Plate I.

Figure I.

For side ZD .

Radius,				
: Sine Co-angle ZpD	37	57	48	9 7889864
:: Tangent pZ	29	38	12	9 7550557
: Tangent pd	19	17	20	9 5440421
pD	89	26	43	
Dd	70	9	23	Sine

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Sine Co	pd	70	42	40	9	9749099
: Sine Co	pd	19	50	37	9	5307810
:: Sine Co	pZ	60	21	48	9	9391086
: Sine Co	ZD	18	12	56	9	4949797
		90				
D 's zen. dist. = ZD		71	47	4		

For angle pDZ .

Sine	pd	70	9	23	9	9734755
: Sine	pd	19	17	20	9	5189498
:: Tangent angle ZpD		52	2	12	10	1077631
: Tangent angle pDZ		24	13	55	9	6532974
= m or the parallactic angle.						

For the moon's distance from the earth in semi-diameters of the earth. Plate I. Fig. II:

Sine angle BAC = the moon's horizontal parallax from sun,	} $0^{\circ} 53' 50''$ 8 1947596					
: BC, the earth's semi-diameter, 1						
:: Radius						
: AC, the moon's distance from the earth's center,	} 63 8617* 10 8052404					

For

* This is not strictly the moon's distance from the earth, because her horizontal parallax from the sun is here used, instead of her true parallax; but the number thus found is to be taken for the next process, because, in these calculations, we find her parallax in altitude, latitude and longitude from the sun, to prevent separate processes for his parallaxes. When we are making these calculations in occultations of the fixed stars by the moon, her true horizontal parallax will necessarily be used, because the fixed stars have no discoverable parallax.

For the moon's parallax in altitude. Plate I, Fig. III.

Sum of the three angles,	180° 0' 0"
Angle BCA = D's zenith distance,	71 47 4
Sum of the two unknown $\angle$'s	180 12 56
Half sum	54 6 28
Side CA = D's distance from the earth's center,	63 8617
Side BC = earth's femi-diameter,	1
Sum of the two sides including the known angle,	64 8617
Their difference,	62 8617
The sum of the two sides including the known angle,	64 8617 1 8119883
: Their difference,	62 8617 1 7983861
:: Tangent $\frac{1}{2}$ sum of the two unknown angles,	54° 6' 28" 10 1404579
: Tangent $\frac{1}{2}$ their difference,	53 15 5 10 1268557
Lesser angle BAC or D's paral- lax in altitude from sun,	51 23 60
	3083

The finding of the moon's parallax in altitude, from her true zenith distance, may be much facilitated by the following short table, which I have calculated for the purpose.

TABLE.

T A B L E.

D's horiz. par ^x .	Logarithms.	Difference.
53	0 0133919	2526
54	0 0136445	2526
55	0 0138971	2526
56	0 0141497	2527
57	0 0144024	2527
58	0 0146551	2527
59	0 0149078	2528
60	0 0151606	2528
61	0 0154134	2528
62	0 0156662	

The first column of this table contains the moon's horizontal parallaxes in minutes. In the second column are the logarithms, which are to be subtracted from the logarithmic tangent of the half sum of the two unknown angles (found as above) according to the moon's horizontal parallax. The remainder will be the logarithmic tangent of the half difference of those angles. The degrees, &c. answering to this, being subtracted from the half sum, will give the parallax in altitude.

The use of the table exemplified.

Required the moon's parallax in altitude from the sun, her horizontal parallax from the sun being $53^{\circ} 50'$, and her true zenith distance $71^{\circ} 47' 4''$, as before.

The Tang. $\frac{1}{2}$ sum of the two unknown angles, as above, } $54^{\circ} 6' 28''$ 18 1404579

Logarithm from the table for $53^{\circ} 50'$ 0 0136024

The Tang. $\frac{1}{2}$ difference of the two unknown angles, } $53^{\circ} 15' 5''$ 9 1268555

The moon's parallax in altitude from the sun, as before, } $51^{\circ} 23'$

D

For

For the moon's parallax in altitude from the sun by approximation.

Sine of the moon's true zenith } $71^{\circ} 47' 4''$ 9 9776721
distance,

The moon's horiz. par. from the sun, 3230* 3 5092025

Moon's par. in altitude from sun nearly 3068 3 4868746
= $51' 8''$

$71^{\circ} 47' 4''$

The moon's visible zen. dist. nearly $72^{\circ} 38' 12''$ Sine 9 9797448

$3230''$ Log. 3 5092025

The moon's par. in alt. from the sun, 3082, 8 3 4889473

This is but $\frac{2}{10}$ of a second different from the parallax which was found by the direct method.

For the moon's parallax from the sun in longitude and latitude.
Plate I, Figure I.

Radius

: Dm the moon's parallax in altitude from the sun, } $3083''$ 3 4889735

:: Sine angle $pDZ = mDr$ the parallactic angle, } $24^{\circ} 13' 55''$ 9 6132407

: mr the moon's parallax in longitude from the sun, } $1265, 3$ 3 1022142
= $21' 5'', 3$

Radius

: Dm $3083''$ 3 4889735
:: Sine

* The arc of this parallax is so small, that we may use the logarithm of the seconds contained in it, instead of the sine of the arc without any sensible error.

∴ Sine co-angle pDZ $65^{\circ}46'5''$ 9 9599432
 : Or the moon's paral. in lat. from sun, 2811, 3
 $= 46'51'', 3$ 3 4489167

For the moon's visible or augmented semi-diameter.

The Sine of the moon's true zen. dist. 71 47 4 9 9776721
 : The Sine of her visible zen. dist. 72 38 27 9 9797546
 ∴ Her horiz. semi-diameter, $14'44'', 5 = 884'', 5$ 2 9466978
 : Her augmented semi-diameter, 888, 8
 2 9487803

Such is the trigonometrical process, for finding the moon's parallax in latitude and longitude, and her augmented or visible semi-diameter; but astronomers have invented *formulas*, which greatly shorten the work, making it unnecessary to find the moon's zenith distance, parallactic angle, and parallax in altitude. In solar eclipses, the moon's latitude being very small, the *formulas* are quite concise and easy.

Let the parallax in latitude be called x , and in longitude y . Let the co-sine of the altitude of the nonagesimal degree be called C and it's sine D . Let the moon's horizontal parallax or her horizontal parallax from the sun be called p , her *visible* latitude l , and *true* latitude L . Let the distance between the moon's *visible* longitude and the longitude of the nonagesimal degree $= Zpm$ in Plate I, Fig. I, be called b ; the *true* $= ZpD$, B. Then, the *visible* latitude and longitude of the moon being given,

$$x = pC \mp pD \text{ sine } l \text{ co-sine } b,$$

$$y = pD \text{ sine } b.$$

The subtractive sign — is to be used, when the moon's latitude is north, the additive + when it is south.

In occultations, when the moon's latitude is large,

$$x = pC \text{ co-fine } l \mp pD \text{ fine } l \text{ co-fine } b.$$

$$y = \frac{pD \text{ fine } b}{\text{Co-fine } L} \left. \begin{array}{l} \text{i. e. } y, \text{ found by } pD \text{ fine } b, \text{ must be enlarged,} \\ \text{in ratio of the co-fine of the moon's true la-} \\ \text{titude to Radius.} \end{array} \right\}$$

Formulas have been invented to find the parallaxes in a direct way, when the moon's *true* latitude and longitude are given; but it is rather easier, in this case, to come at them by approximation, thus,

Add together logarithm p , fine D, fine B, which will give y , or the parallax in longitude nearly. Add the parallax thus found to B, which will give b nearly, viz. the distance between the moon's *visible* longitude and the longitude of the nonagesimal degree. Then log. p , fine D, fine b thus nearly found, will give y , the parallax in longitude, sufficiently exact; and this added to B will give correct b . Add together log. p , fine C, which will give x , or the parallax in latitude nigh the truth. This being properly applied to L, the moon's *true* latitude, will make l , the *visible* latitude, nearly. Then add together log. p , fine D, fine l , thus nearly found, and co-fine b , which give the logarithm of a number, that added to, or subtracted from x , as before nearly found, will make the correct parallax in latitude.

With respect to the moon's augmented semi-diameter we may say $B : C ::$ the moon's horizontal semi-diameter : her augmented

mented semi-diameter. Her augmented semi-diameter, thus found, will be sufficiently correct for all purposes.

Exemplification.

The co-altitude of the nonagefimal degree, $\left. \begin{array}{l} 60^{\circ} 21' 48'' \text{ Sine } 9 \ 9391086 \ C \end{array} \right\}$

The altitude of the nonagefimal degree, $\left. \begin{array}{l} 29 \ 38 \ 12 \text{ Sine } 9 \ 6941647 \ D \end{array} \right\}$

The moon's horiz. par. from the sun, $\left. \begin{array}{l} 53' 50'' = 3230'' \text{ Log. } 3 \ 5092025 \ p \end{array} \right\}$

The dist. between the moon's true long. and the long. of the nonagefimal degree, $\left. \begin{array}{l} 52 \ 2 \ 12 \text{ Sine } 9 \ 8967492 \ B \end{array} \right\}$

The moon's true latitude, $33 \ 17 \ N = L$

$p \ 3 \ 5092025$

$D \ 9 \ 6941970$

$B \ 9 \ 8967492$

$y \text{ nearly } 1259'' \ 3 \ 1001487$

$= 20' \ 59''$

$B \ 52 \ 2 \ 12$

$b \text{ nearly } 52 \ 23 \ 11 \text{ Sine } 9 \ 8988045$

$pD \ 3 \ 2033995$

$1265'', 3 \ 3 \ 1022040$

$= 21' \ 5'', 3 \ D's \text{ parallax in long. from } \odot$

$B \ 52 \ 2 \ 12$

$b \text{ correct } 52 \ 23 \ 17 \text{ Sine } 9 \ 8988143$

$$\begin{array}{r}
 p \ 3 \ 5092025 \\
 C \ 9 \ 9390986 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 x \text{ nearly } 2807'' \cdot 4 \quad 3 \ 4483011 \\
 = 46' \ 47'' \quad S \\
 D's \text{ true lat.} = L \ 33 \ 17 \quad N
 \end{array}$$

$$\begin{array}{r}
 + \\
 I \text{ nearly, viz. } D's \text{ vis. lat. } 13 \ 30 \ S \text{ Sine } 7 \ 5940588
 \end{array}$$

$$\begin{array}{r}
 pD \ 3 \ 2033995 \\
 Co-fine \ b \ 9 \ 7855507 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 3'' \cdot 8 \quad 9 \ 5830090 \\
 x \text{ nearly } 46' \ 47'' \cdot 4 \\
 + \quad 3'' \cdot 8
 \end{array}$$

$$x \text{ correct } 46 \ 51, \ 2 \ D's \text{ parallax in lat. from } \odot$$

$$\begin{array}{r}
 \text{Sine } B \quad 52^\circ \ 2' \ 12'' \quad 9 \ 8967492 \\
 : \text{ Sine } b \quad 52 \ 23 \ 17 \quad 9 \ 8988143 \\
 :: \text{ The moon's horiz. } \left. \begin{array}{l} \text{femi-diameter,} \\ \text{Her augmented or visible} \end{array} \right\} 14' \ 44'', \ 5 = 884'', \ 5 \quad 2 \ 9466978 \\
 \text{femi-diameter,} \\
 : \text{ Her augmented or visible } \left. \begin{array}{l} \text{femi-diameter,} \end{array} \right\} 888, \ 8 \quad 2 \ 9487629 \\
 = 14' \ 48'', \ 8
 \end{array}$$

By these results it appears that the foregoing *formulas* find the parallaxes and augmented femi-diameter of the moon to great exactness.

Let us now find the visible difference of longitude between the center of the sun and moon, at Greenwich, at $5^h \ 29' \ 57''$, when the eclipse begun there. Plate I, Fig. IV.

The

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The ☉'s horizontal semi-diameter, 15' 47", 0
 The ♃'s augmented semi-diameter, 14 48, 8

Sum, 30 35, 8

Subtract for inflection, 4, 5

Visible distance of centers, 30 31, 3
 60

Hypotenuse ☉♃ 1831, 3

The ♃'s parallax in latitude from ☉, 46' 51", 2 S

The moon's latitude, — 33 17, 0 N

The ♃'s visible latitude from ☉, 13 34, 2 S
 60

Side E♃ 814, 2

Hypotenuse ☉♃ 1831, 3

Side E♃± 814, 2

Sum, 2645, 5 3 4225078

Difference, 1017, 1 3 0073637

2 | 6 4298715

Side ☉E = the visible diff. long. of } 1640, 3 3 2149357
 ☉'s and ♃'s center, }
 = 27 20, 3

For the moon's true longitude according to observation.

From the sun's true long. aug. 5^d. 5^h. 29' 57" 4^s. 13° 9' 51", 0

Subtract ☉'s and ♃'s visible diff. long. by observation, 27 20, 3

Remains

Remains the D 's visible longitude nearly, $4\ 12\ 42\ 30, 7$
 Add the moon's parallax in longitude from the $\odot$. $+ 21\ 5, 3$

The sum is the D 's true long. according to observ. $4\ 13\ 3\ 36, 0$

The true diff. of long. of $\odot$ and D according to observa. $6\ 15$
 60

375

Let us now find the requisites for $7^{\text{h}}\ 11'\ 33\frac{1}{2}''$ when the eclipse ended at Greenwich.

Elements for computing the parallaxes, &c. at $7^{\text{h}}\ 11'\ 33\frac{1}{2}''$

The sun's longitude, $4^{\text{s}}\ 13^{\circ}\ 13'\ 54'', 5$

The moon's ecliptic longitude, $4\ 13\ 53\ 55, 6$

The moon's latitude north, $28\ 40, 6$

The sun's right ascension, $135\ 42\ 33$

The right ascension of the mid-heaven, $243\ 35\ 55$

Angle $p\text{PZ}$, $26\ 24\ 5$

Complement, $63\ 35\ 55$

Side PZ as before, as also the D 's horizontal parallax.*

From these elements are found

The altitude of the nonagesimal degree, $20^{\circ}\ 11'\ 5''$

Angle PpZ , $126\ 12\ 38$

The longitude of the nonagesimal degree, $7^{\text{s}}\ 6\ 12\ 38$

Angle

* As the moon was near her apogee, the horizontal parallax altered so very little, in a few hours, that the same may here be taken for the end, as for the beginning. If the moon is not near her apogee or perigee, at the time of a solar eclipse, allowance should be made for the alteration of the horizontal parallax, between the beginning and end.

Angle $ZpD = B$, $82^{\circ} 18' 42''$
 The moon's parallax in longitude from the sun, $18 \ 25, \ 3$
 The moon's parallax in latitude from the sun, $50 \ 32, \ 5 \ S$
 The moon's augmented semi-diameter, $14 \ 45, \ 1$
 The sum of the $\odot$'s and D 's semi-diameters $4'', 5$ } $1827, 6''$
 for inflection $= \odot \text{D}$
 The moon's visible latitude from the $\odot = Ed$ $1311, \ 9 \ S$
 The visible diff. of long. of the $\odot$'s & D 's centers $= \odot E$ $1272, \ 4$
 $= 21' \ 12'', \ 4$
 To the sun's true longitude at $7^h \ 11' \ 33'', \ 4$ $13^{\circ} 13' \ 54'', \ 5$
 Add the visible diff. of long. of $\odot$ and D by observ. $+ 21 \ 12, \ 4$

 The sum is the D 's visible longitude nearly, $4 \ 13 \ 35 \ 6, \ 9$
 Add the D 's parallax in long. from the sun, $+ 18 \ 25, \ 3$

 The sum is the D 's true long. according to obs. $4 \ 13 \ 53 \ 32, \ 2$

 The true diff. of long. of $\odot$ and D at the end by obs. $39 \ 37, \ 7$
 60

 $= 2377, 7$
 The true diff. by observation at the beginning, $+ 375, 0$

 The whole motion of the D from the $\odot$ in } $2752, 7$
 the ecliptic by observation, }
 By Mayer's tables
 The moon's long. at the beginning of the eclipse, $4^s \ 13^{\circ} \ 3' \ 59'', 0$
 Ditto at the end, $4 \ 13 \ 53 \ 55, 6$

 The difference $=$ the moon's whole motion } $49 \ 56, 6$
 during the eclipse, }
 E The

The sun's motion for the same time,

$$= 4' 3'' 5$$

The whole motion of the γ from the $\odot$ by Mayer's tables 45 53, 1

60

2753, 11

By this it appears, that the whole motion of the moon from the sun in the ecliptic, by observation, differs but $0''$, 4 from that given by the tables : Therefore, if we suppose the horary motions by these to be correct, the latitude will be nearly exact, the observations being allowed good.

For the time of the true conjunction of the sun and moon according to observation.

The beginning of the eclipse by obs. at Greenwich, 5^h. 29' 57''

The end, 7 11 33 $\frac{1}{2}$

The difference = the duration 1 41 36 $\frac{1}{2}$

60

101

60

6096 $\frac{1}{2}$

The whole motion of γ from } 2752^h, 7 3 4397589
the $\odot$ during the eclipse, }

: The time of the duration, 6096 $\frac{1}{2}$, 3 7850806

:: Diff. long. γ & $\odot$ at the beginning by obs. 375, 0 2 5740313

: The time from the begin. to ecliptic conj. 830 $\frac{1}{2}$ 2 9193530

= 13' 50'' $\frac{1}{2}$

To

To the time of the beginning of the eclipse by observ. $5^h 29^m 57^s$

Add $13^m 50^s$

The sum is the time of ecliptic conjunction by observ. $5^h 43^m 47^s$

SCHOLIUM.

From the observation of the beginning or ending of a solar eclipse, at a place, for which astronomic tables have been constructed, or, at a place, whose difference of longitude from that, for which the tables have been constructed, is accurately ascertained, the error in the moon's longitude as given by them, may be known, if they have given her latitude exact, or the error, if there be one, has been corrected by observation. For example, when the foregoing eclipse began at Greenwich, the moon's longitude, by Mayer's printed tables, was $4^h 13^m 3^s 59''$, 0, but, deduced from the observations, it was but $4^h 13^m 3^s 36''$, 0; the error of these tables, therefore, in the moon's longitude, at that time, was $+ 23''$, supposing the latitude exact. By the observation of the end the error was $23''$, 4.

Having found the time of the ecliptic conjunction of the sun and moon, at Greenwich, as deduced from the observations of the beginning and ending of the eclipse, we are next to find the conjunction at Cambridge, from the observations made there.

Let us assume the difference of meridians between Greenwich and Cambridge to be $4^h 44^m 25^s$, then, at $11^h 39^m 23^s$, A. M. when the eclipse began at Cambridge, it was $4^h 23^m 48^s$, P. M. at Greenwich; and the sun's longitude and right ascension, and the moon's latitude and longitude were the same, at each place.

Having found these for Greenwich, at $5^h 29' 57''$, P. M. it will be easy to obtain them for $4^h 23' 48''$, answering to $11^h 39' 23''$ at Cambridge, by the solar and lunar motions for $1^h 6' 9''$, the difference between $5^h 29' 57''$ and $4^h 23' 48''$.

Elements for Cambridge at $11^h 39' 23$, A. M.

The sun's longitude,	$4^s 13^{\circ} 7' 12'' 5$
The moon's ecliptic longitude,	$4 12 31 28, 1$
The moon's latitude north,	$36 16, 8$
The moon's horizontal parallax,	$54 10, 5$
The sun's right ascension,	$135 35 35$
The right ascension of the mid-heaven,	$130 26 20$
Angle pPZ	$139 33 40$
	$= 40 26 20$
	Complement $49 33 20$
The latitude of Cambridge,	$42 23 28 N$
Reduced to the center,	$42 8 37$
	Complement $= PZ 47 51 23$

From these elements are found,

The altitude of the nonagesimal degree,	$67 0 6$
Angle PpZ	$31 30 11$
The longitude of the nonagesimal degree,	$4 1 30 11$
Angle $ZpD = B$	$11 1 17$
The moon's parallax in longitude from the sun,	$9 36, 8$
The moon's parallax in latitude from the sun,	$20 49, 9 S$
The moon's augmented semi-diameter,	$14 57, 2$
The sum of the $\odot$'s and D 's semi-diameter—	$4' 51$
for inflection $= \odot D$,	$18 39, 7$
The moon's visible latitude from the sun $= Ed$,	$9 26, 9 N$
The	

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The visible diff. of long. of the ☉'s & ☾'s centers = ☉E 1589', 1
= 26' 29'', 1

From the sun's true longitude at Cambridge, } 4^s. 13° 7' 12, 5
at 11^h 39' 23'', }

Subtract ☉'s and ☾'s visible diff. long. by observation, — 26 29, 1

Subtract the moon's parallax of longitude from ☉, — 9 36, 8

The moon's true long. according to observa. 4 12 31 6, 6

The true diff. of long. of ☉ & ☾ according to observa. 36 5, 9
60

2165, 9

Elements for the end of the eclipse at Cambridge, at 2^h 45'
9'', P. M.

The sun's longitude, 4^s. 13° 14' 37", 7

The moon's ecliptic longitude, 4 14 2 46, 7

The moon's latitude north, 27 51, 5

The sun's right ascension, 135 43 1

The right ascension of the mid-heaven, 177 0 16

Angle pPZ 92 59 44

= 87 0 16

Complement

From these elements are found,

The altitude of the nonagesimal degree, 53 7 38

Angle PpZ, 67 45 32

The longitude of the nonagesimal degree, 5 7 45 32

Angle

Angle $Zp\gamma = B$,	$23^{\circ}42'45''$
The moon's parallax in longitude from the sun,	17 31, 7
The moon's parallax in latitude from the sun,	32 22, 5
The moon's augmented semi-diameter,	14 54, 7
The sum of the $\odot$'s and γ 's semi-diameters — $4''5$ } for inflection = $\odot\gamma$,	1837, 2
The moon's visible latitude from the $\odot = E\gamma$,	271, 5
The visible diff. of long. of $\odot$'s and γ 's centers = $\odot E$	1817, 1
	= 30 17, 1
To the sun's true longitude at Cambridge, } at $2^h 45' 9''$,	$4^s 13 14 37, 7$
Add $\odot$'s and γ 's visible diff. long. by observation, +	30 17, 1
	4 13 44 54, 8
Add the moon's parallax of longitude from $\odot$,	+ 17 31, 7
The true long. of the moon according to obsf.	4 14 2 26, 5
The true diff. of long. of $\odot$ and γ according to observa.	47 48, 8
	60
	2868, 8
The true difference by observation at the beginning } $11^h 39' 23''$, A. M.	2165, 9
The whole motion of γ from $\odot$ in the ecliptic by obsf.	5034, 7
By Mayer's tables,	
The moon's long. at the beginning of the eclipse,	$4^s 12^{\circ}31'28'', 1$
Ditto at the end,	4 14 2 46, 7
Diff. = γ 's whole motion in the ecliptic during } the eclipse,	1 31 18, 6

The

The sun's motion for the same time, $7^{\circ} 25' 2''$

The whole motion of Δ from $\odot$ by Mayer's tables, $1^{\circ} 23' 53'' 4$

60

83

60

$5033, 4$

By this it appears that the whole motion by observation differs but $1'' 3$ from that given by Mayer's tables.

The time of the duration of the eclipse by observation was $111146''$.

For the time of the true conjunction of the sun and moon at Cambridge by observation.

The whole motion of Δ from $\odot$ in the } $5034'', 7 \ 3 \ 7019736$
ecliptic during the eclipse,

The time of the duration, $111146 \ 4 \ 0471190$

Diff. long. Δ and $\odot$ at the begin. by observ. $2165, 9 \ 3 \ 3356384$

The time from the beginning to the } $4795 \ 3 \ 6807838$
ecliptic δ by observation,

$= 79^{\circ} 55'$

Add this time, $= 1^h 19 \ 55$

To the time of the beginning by observa. $11 \ 39 \ 23$

The sum is the time of ecliptic δ by observa. $0 \ 59 \ 18$

Time of ecliptic δ at Greenwich by observa. $5 \ 43 \ 47\frac{1}{2}$

Diff. $=$ the diff. of meridians between } $4 \ 44 \ 29\frac{1}{2}$
Greenwich & Cambridge by observa.

Thus

Thus it appears, that according to the observations of this eclipse made at Greenwich and Cambridge, the difference of meridians between those places is $4^h 44' 29\frac{1}{2}''$; so that the time that was assumed for the difference was very near the truth. If the difference of meridians, thus deduced, is in any case considerably different from that which was assumed, this result is to be considered as only the approximate difference, and is to be used as a new-assumed difference, from which deductions are to be made for the true. If the first result does not differ more than two or three minutes from the assumed difference of meridians, the same parallax in longitude and latitude may be used in the second process, which were found and used in the first; because the right ascension of the mid-heaven will not differ more than $6''$ or $8''$ from the first = the difference in the sun's right ascension, which, together with the small difference in the moon's longitude and latitude, will make so trifling a difference in her zenith distance and parallactic angle, that the difference of parallaxes will be inconsiderable. All, therefore, that is necessary to be done, in the second process, is to find the sun's longitude and the moon's latitude for the approximate or new assumed difference of meridians, from whence, with the parallaxes, we must deduce the difference of longitude between the sun and moon, whereby the true conjunction will be obtained.

For illustration, let us take the foregoing observations of the solar eclipse, and assume $4^h 42' 25''$ for the difference of meridians between Greenwich and Cambridge.

According to this assumption, at $11^h 39' 23''$, A. M. when the eclipse began at Cambridge,

The

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The sun's longitude by the tables,	4 ^s . 13° 7' 7".7
The moon's ecliptic longitude,	4 12 30 29, 1
The moon's latitude,	36 22, 2
The sun's right ascension,	135 35 30
The right ascension of the mid-heaven,	130 26 15
Angle pPZ	139 33 45
=	40 26 15
Complement	49 33 45

Hence

The altitude of the nonagesimal degree,	67 0 7
Angle PpZ ,	31 29 49
The longitude of the nonagesimal degree,	4 1 29 49
Angle $ZpD = B$,	11 0 40
The moon's parallax in longitude from the sun,	9 36, 3
The moon's parallax in latitude from the sun,	20 49, 88
$\odot D$ as before,	1839",7
ED or the moon's visible latitude from the sun,	932, 4
The visible diff. of long. of $\odot$'s and D 's centers = $\odot E$	1585, 9
	= 26' 25",9
The D 's ecliptic long. by observa. according to the above assumption,	} 4 ^s . 12° 31' 5, 5
The true diff. of long. of $\odot$ and D by observation according to the assumption,	
	36 2, 2
	60
	2162, 2

At the end of the eclipse at Cambridge at 2^h. 45' 9" according to the above assumption,

F

The

The sun's longitude,	4 ^s . 13° 14' 32", 9
The moon's ecliptic longitude,	4 14 1 47, 7
The moon's latitude,	27 56, 9
The sun's right ascension,	135 42 56
The right ascension of the mid-heaven	177 0 11
Angle pPZ ,	92 59 49
	= 87 0 11
Complement	2 59 49

Hence

The altitude of the nonagesimal degree,	53 7 40
Angle PpZ	67 45 30
The longitude of the nonagesimal degree,	5 7 45 30
Angle $ZpD = B$	23 43 42
The moon's parallax in longitude from the sun,	17 31, 7
The moon's parallax in latitude from the sun,	32 22, 4
$\odot D$ as before,	1837", 2
ED	265, 5
The visible diff. of long. of $\odot$'s and D 's centers = $\odot E$	1817, 9
	= 30' 17", 9
The moon's ecliptic long. by observation } according to the above assumption, }	4 14 2 22, 5
The true diff. of long. of $\odot$ and D by observa. at the end } of the eclipse, according to the assumption, }	47 49, 6
	60
	2869, 6
The difference at the beginning as above,	2162, 2
The whole motion of D from $\odot$ accord. to this assum.	5031, 8
	5031", 3

$$5031'', 8 : 11146'' :: 2162'', 2 : 4789\frac{1}{2}'' = 1^h 19' 49\frac{1}{2}''$$

The beginning of the eclipse at Cambridge, 11 39 23

The ecliptic δ of $\odot$ and D by observa. according } $0 59 12\frac{1}{2}$
to the foregoing assumption,

Time of δ at Greenwich by observation, 5 43 47 $\frac{1}{2}$

The difference of meridians by this assumption, 4 44 35

By this it appears, that the assumed difference of meridians, viz. $4^h 42' 25''$, differs much from the truth : But the parallaxes resulting from this assumption, are so very near those resulting from the first, that it is evident they may be employed in the remaining part of the process, without causing any sensible error. Let $4^h 44' 35''$, the difference of meridians now found, be used as a new-assumed difference, which will give the moon's latitude at the beginning of the eclipse at Cambridge $36' 16''$, 5, and at the end $27' 51''$, 2, and by a proper process we shall find the visible difference of longitude of $\odot$ and D at the beginning $1589''$, 3, and the true difference $2165'$, 6 ; and at the end the visible difference $1817''$, 1, and the true $2868''$, 8. Hence we find the time of ecliptic conjunction at Cambridge $0^h 59' 17\frac{1}{2}''$, and the difference of meridians between Cambridge and Greenwich $4^h 44' 30''$, but half a second different from what it was at first found.

If instead of finding the difference of meridians at once, by the conjunction at each place, any one chuses to find it by the beginning and end separately, he may easily do it.

At the beginning of the foregoing eclipse at Greenwich, it appears, that the moon's ecliptic longitude by observation was $4^{\text{s}}. 13^{\circ} 3' 36'', 0$, but when it began at Cambridge, her longitude by observation was but $4^{\text{s}}. 12^{\circ} 31' 6''$. The difference is $32' 29'', 4 = 1949'', 4$. Let us find how long the moon was in passing over this portion of the ecliptic, thus,

$$\begin{array}{rcl}
 \text{The } \mathfrak{D}'\text{s horary mot. in long. } 29' 29'', 5 & = & 1769'', 5 \quad 3 \ 2478506 \\
 : 1 \text{ hour,} & & 3600 \quad 3 \ 5563025 \\
 :: & & 1949, 4 \quad 3 \ 2899010 \\
 & & \hline
 : & & 3966 \quad 3 \ 5983529 \\
 & & = 1^{\text{h}}. 6' 6''
 \end{array}$$

By this it appears, that it was $1^{\text{h}}. 6' 6''$ after the eclipse began at Cambridge, before the moon had the same longitude, as when the beginning was observed at Greenwich : Therefore, to $11^{\text{h}}. 39' 23''$, A. M. add $1^{\text{h}}. 6' 6''$; the sum $0^{\text{h}}. 45' 29''$, shews the time at Cambridge, when she had the same longitude as at Greenwich at $5^{\text{h}}. 29' 57''$; and the difference $4^{\text{h}}. 44' 28''$ is the difference of meridians in time, between those two places as deduced from the observations of the beginning of this eclipse. By a similar process, we find the difference resulting from the observations of the end to be $4^{\text{h}}. 44' 31\frac{1}{2}''$. The mean is $4^{\text{h}}. 44' 29\frac{3}{4}''$.

Another solar eclipse, the observations of which we make use of, to determine the difference of meridians between Greenwich and Cambridge, is that of June 24, 1778. As the clouds were troublesome, at that time, at Cambridge, and consequently

By the observations somewhat uncertain, we may take the observation of the end of the eclipse made at Chelsea, by the Rev. Mr. Payson, who had a very favourable time. And as Mr. Payson and I have, by terrestrial measurement, made with much precision, found Chelsea to be 26'' in time east of Cambridge, this observation is the same to our purpose, as if made in Cambridge.

The beginning of this eclipse was observed by the Rev. Dr. Nevil Maskelyne, at the Royal Observatory at Greenwich, at 3^h 40' 11'', and the end at 5^h 25' 12'' apparent time.* At Chelsea, the end was observed by the Rev. Phillips Payson, at his own house, at 1^h 38' 23'', A. M. apparent time.

At the Royal Observatory at Greenwich, at 3^h 40' 11'' apparent time.

The sun's longitude by Mayer's tables, 3^s 3° 4' 2'', 0
The moon's ecliptic longitude, 3 3 6 32, 0
The

* I am indebted to Mr. De La Lande, a celebrated member of the Royal Academy of Sciences at Paris, for the European observations of this eclipse; who, in a very obliging manner, in a letter of November 30, 1781, communicated them to me. They are as follow:

At Oxford,	Greenwich,	Deptford,	Stockholm,	Paris,
Beg. 3 ^h 33' 44"	3 ^h 40' 11"	3 ^h 40' 12"	5 ^h 4' 19"	3 ^h 53' 15" or 13"
End. 5 19 48	5 25 12	5 25 11½	6 13 25	
Marfeilles,	Padua,	Milan,	Cadiz,	Toulouſe,
Beg. 4 12 0	4 41 46	4 29 9	3 18 53	3 52 27 or 24 or 22
End. 6 1 46	6 21 41	6 12 0	5 26 25	

As the beginning only was observed at Paris, I have taken the observations made at Greenwich, where the end as well as the beginning of the eclipse was seen.

The moon's latitude north increafing,	19' 20", 7
The fun's horary motion,	2 23, 0
The moon's horary motion in long. in the ecliptic,	37 36, 3
The moon's horary motion in latitude,	3 9, 8
The moon's horizontal parallax,	61 7, 6
The fun's horizontal parallax,	8, 4
The fun's right afcenfion,	93° 20 36
The right afcenfion of the mid-heaven,	148 23 21
Angle pPZ ,	121 36 39
	= 58 23 21
Complement	31 36 39
The fun's femi-diameter,	15 47
The moon's horizontal femi-diameter,	16 40, 3
The obliquity of the ecliptic,	23 28 6
PZ , &c. as before,	

Hence

The altitude of the nonagefimal degree,	54 13 45
Angle PpZ ,	41 5 7
The longitude of the nonagefimal degree,	4 11 5 7
Angle $ZpD = B$,	37 58 35
The moon's parallax in longitude from the fun,	30 47, 6
The moon's parallax in latitude from the fun,	35 50, 1
The moon's augmented femi-diameter,	16 51, 8
The fum of $\odot$'s & $\textcircled{D}$'s femi-diam.—4", 5 for infl. = $\odot D$,	1954", 3
The moon's vifible lat. from the fun = ED	989, 4
The vifible diff. of long. of $\odot$'s and $\textcircled{D}$'s centers $\odot E$,	1685, 3
	= 28' 5", 3
The moon's ecliptic long. by obfervation,	3 ^s . 3° 6 44, 3

At

MATHEMATICAL PAPERS. 47

At the Royal Observatory at Greenwich, at 5^h 25' 12" apparent time.

The sun's longitude,	3 ^s . 3° 8' 12'', 2
The moon's ecliptic longitude,	3 4 12 21, 0
The moon's latitude north,	42 52, 8
The sun's right ascension,	93 25 8
The right ascension of the mid-heaven,	174 43 8
Angle pPZ,	95 16 52
	= 84 43 8
Complement	5 16 52

Hence

The altitude of the nonagesimal degree,	46 11 19
Angle PpZ	59 45 50
The longitude of the nonagesimal degree,	4 29 45 50
Angle ZpD = B,	55 33 29
The moon's parallax in longitude from the sun,	36 33, 5
The moon's parallax in latitude from the sun,	42 20, 7
The moon's augmented semi-diameter,	16 47, 8
The sum of ☉'s & D's semi-diam. — 4'', 5 for infl. = ☉D, 1950'', 3	
The moon's visible lat. from the sun = ED,	1047, 9
The visible diff. of long. of ☉'s and D's centers = OE,	1644, 9
	= 27' 24'', 9
The moon's ecliptic long. by observation,	3 ^s . 4° 12 10, 6

Hence it appears, that the motion of the moon by observation, during the eclipse, with respect to the ecliptic, was 1° 5' 26'', 3; but, by Mayer's tables, it was 1° 5' 49''. Supposing then the horary motion by the tables to be true, as is most probable, we may conclude, that there is an error in the moon's latitude,

The moon's latitude north increafing,	19' 20", 7
The fun's horary motion,	2 23, 0
The moon's horary motion in long. in the ecliptic,	37 36, 3
The moon's horary motion in latitude,	3 9, 8
The moon's horizontal parallax,	61 7, 6
The fun's horizontal parallax,	8, 4
The fun's right afcenfion,	93° 20 36
The right afcenfion of the mid-heaven,	148 23 21
Angle pPZ ,	121 36 39
	= 58 23 21
Complement	31 36 39
The fun's femi-diameter,	15 47
The moon's horizontal femi-diameter,	16 40, 3
The obliquity of the ecliptic,	23 28 6
PZ , &c. as before,	

Hence

The altitude of the nonagesimal degree,	54 13 45
Angle PpZ ,	41 5 7
The longitude of the nonagesimal degree,	4 11 5 7
Angle $ZpD = B$,	37 58 35
The moon's parallax in longitude from the fun,	30 47, 6
The moon's parallax in latitude from the fun,	35 50, 1
The moon's augmented femi-diameter,	16 51, 8
The fum of $\odot$'s & $\textcircled{D}$'s femi-diam.—4'', 5 for infl. = $\odot D$,	1954'', 3
The moon's vifible lat. from the fun = $E D$	989, 4
The vifible diff. of long. of $\odot$'s and $\textcircled{D}$'s centers $\odot E$,	1685, 3
	= 28' 5'', 3
The moon's ecliptic long. by obfervation,	3 ^s . 3° 6 44, 3

At

MATHEMATICAL PAPERS. 47

At the Royal Observatory at Greenwich, at 5^h 25' 12" apparent time.

The sun's longitude,	3 ^s . 3° 8' 12'', 2
The moon's ecliptic longitude,	3 4 12 21, 0
The moon's latitude north,	42 52, 8
The sun's right ascension,	93 25 8
The right ascension of the mid-heaven,	174 43 8
Angle pPZ ,	95 16 52
	= 84 43 8
Complement	5 16 52

Hence

The altitude of the nonagesimal degree,	46 11 19
Angle PpZ	59 45 50
The longitude of the nonagesimal degree,	4 29 45 50
Angle $ZpD = B$,	55 33 29
The moon's parallax in longitude from the sun,	36 33, 5
The moon's parallax in latitude from the sun,	42 20, 7
The moon's augmented semi-diameter,	16 47, 8
The sum of $\odot$'s & $\textcircled{D}$'s semi-diam.—4'', 5 for infl. = $\odot D$, 1950'', 3	
The moon's visible lat. from the sun = ED ,	1047, 9
The visible diff. of long. of $\odot$'s and $\textcircled{D}$'s centers = $\odot E$, 1644, 9	
	= 27' 24'', 9
The moon's ecliptic long. by observation,	3 ^s . 4° 12' 10, 6

Hence it appears, that the motion of the moon by observation, during the eclipse, with respect to the ecliptic, was 1° 5' 26'', 3; but, by Mayer's tables, it was 1° 5' 49''. Supposing then the horary motion by the tables to be true, as is most probable, we may conclude, that there is an error in the moon's latitude,

latitude, as given by them, the correction of which may be found, in the manner following :

The ν 's longitude at the beginning, per tables, $3^{\text{h}} 3^{\text{m}} 6' 32'', 0$

The ν 's parallax in longitude from $\odot$ $\text{---} 30\ 47, 6$

$3\ 2\ 35\ 44, 4$

The ν 's longitude at the end per tables,

$3\ 4\ 12\ 21, 0$

The ν 's parallax in longitude from $\odot$ $\text{---} 36\ 33, 5$

$3\ 3\ 35\ 47, 5$

Subtract

$3\ 2\ 35\ 44, 4$

Difference

$1\ 0\ 3, 1$

Subtract $\odot$'s motion during the eclipse,

$\text{---} 4\ 10, 2$

Remains ν 's visible motion from $\odot$ per tables,

$55\ 52, 9$
 60

$3352, 9$

The ν 's visi. lat. from $\odot$ by calculation at beginning, $989'', 4$

At the end,

$1047, 9$

The ν 's visible motion in latitude from the $\odot$,*

$58, 5$

In plate I. fig. I. let $E\odot C$ be a portion of the ecliptic $\S = 3352'', 9$ the moon's visible motion from the sun, during the eclipse.

* The moon's visible motion as it arises from her horary motion and parallaxes in latitude, is not affected by the small error in the latitude given by the tables.

$\S$ See note, page 17.

eclipse. Let $\sphericalangle E$ be = the moon's visible latitude from the sun, at the beginning of the eclipse, and CL the same at the end. Let $\sphericalangle M$ be drawn parallel to $E\odot C$; then, $ML = 58''.5$ will be the moon's visible motion in latitude from the sun, during the eclipse, and $M\sphericalangle L$, the visible angle of the moon with the sun in the ecliptic.* Let $\sphericalangle \odot$ be the distance of the $\odot$'s and $\sphericalangle$'s centers, at the beginning of the eclipse, and $\odot L$ the same at the end; then the point at $\odot$ will be the place of the ecliptic conjunction; and the line $\odot D$, perpendicular to the ecliptic, and cutting the moon's visible path $\sphericalangle L$ in D , will be the moon's visible latitude from the sun, at the time of the ecliptic conjunction; and the line $\odot N$, perpendicular to the visible path, and cutting it in N , will be the least distance of centers.

$\sphericalangle M$	3352'',9	3	5254206
: ML	58, 5	1	7675269
:: Radius		10	
: Tangent angle $M\sphericalangle L$,	1° 0' 2''	8	2421063
Sine angle $M\sphericalangle L$,	1 0 2	8	2420401
: ML	58, 5	1	7675269
:: Radius		10	
: $\sphericalangle L$	3353, 4	3	5254868
$\sphericalangle L$	3353'',4	3	5254868
: $\sphericalangle \odot + L\odot$	3904, 6	3	5915796
:: $\sphericalangle \odot - L\odot$	4, 0	0	6020600
: Difference $\sphericalangle N$ and LN	4, 6	0	6681528
	G		$\frac{1}{2}\sphericalangle$

* The true side ML is so short in this small figure, that it was necessary to increase it for the sake of illustration; but every one knows that the calculations are not affected by it, the true length being used in them.

$\frac{1}{2}DL$	1676",7	
$\frac{1}{2}$ difference DN and LN	+ — 2, 3	
DN	1679, 0	
LN	1674, 4	
DO	1954, 3	3 2909912
: Radius		10
:: DN	1679, 0	3 2250507
: Sine angle DON	59° 13' 9"	9 9340595
Angle NDD = MDL	+ 1 0 2	
Angle DOD = DOF	60 13 11	
	90	
Angle DOE	29 46 49	
Radius		10
: DO	1954",3	3 2909912
:: Sine angle DOE	29° 46' 49"	9 6959990
: ED	970, 5	2 9869902
D's visible lat. from O =	16' 10, 5 S	
From D's parallax in lat. from O	35 50, 1	
Sub. D's vifi. lat. from O now found	16 10, 5	
Remains D's correct latitude,	19 39, 6 N	
D's lat. by Mayer's tables,	19 20, 7 N	
Error of the tables in D's lat.	— 18, 9*	

* As the time both of the beginning and end of the eclipse is used in deducing this error, there is no need of finding CL, which would give the same.

Thus it appears, by the Greenwich observations of the beginning and end of this eclipse, that the latitude of the moon, given by Mayer's tables, is $18''$, 9 too small,* which correction, being applied, will give her latitude at the beginning $19' 39''$, 6, and at the end $25' 11''$, 7. Hence the visible difference of longitude, at the beginning, was $28' 16''$, 3, and at the end $27' 36''$, 7; and the true longitude by observation $3^s 3^{\circ} 6' 33''$, 3 and $3^s 4^{\circ} 12' 22''$, 4, the difference being $1^{\circ} 5' 49''$, as by the tables. The true difference of longitude between the sun and moon, at the beginning, was $151''$, 3, the moon's longitude being the greatest: Therefore, D's horary motion from $\odot 2113''$, 3 : 1 hour = $3600'' :: 151''$, 3 : $257\frac{3}{4}''$ = $4' 17\frac{3}{4}''$; which being subtracted from $3^h 40' 11''$ (the observed time of the beginning of the eclipse at Greenwich) because the moon had really passed the conjunction, leaves $3^h 35' 53\frac{1}{4}''$ for the apparent time of the true ecliptic conjunction.

Let us now assume $4^h 44' 4''$ for the difference of meridians between Greenwich and Chelsea, and find the elements for Chelsea, at the end of the eclipse, viz. At $11^h 38' 23''$, answering to $4^h 22' 27''$ at Greenwich, according to this assumption.

At Chelsea at $11^h 38' 23''$, A. M. apparent time.

The sun's longitude,	$3^s 3^{\circ} 5' 42''$, 8
The moon's ecliptic longitude,	3 3 33 1, 8
G 2	The

* By the Oxford observations of the beginning and end of this eclipse, the error in latitude, in Mayer's tables, was $-20''$, 6, differing but $0''$, 7 from the error found by the Greenwich observations.

The moon's lat. corrected by the Greenwich observa.	21 53, 2
The moon's horizontal parallax,	61 10, ●
The sun's right ascension,	93 22 25
The right ascension of the mid-heaven	87 58 10
Angle pPZ ,	177 58 10
	= 2 1 50
Complement	87 58 10
The latitude of Chelsea,	42 25 11
Reduced to the center,	42 10 20
Complement = PZ	47 49 40

Hence

The altitude of the nonagesimal degree,	71 17 6
The longitude of the nonagesimal degree,	2 28 24 40
Angle $ZpD = B$	5 8 21
The moon's parallax in longitude from the sun,	5 15, 8
The moon's parallax in latitude from the sun,	19 32, 6
The sum of $\odot$'s & D 's semi-diam.—4'',5 for infl. = $\odot D$,	1959'',8
The moon's visible latitude from the sun,	140, 6
The visible diff. of long. of $\odot$'s and D 's centers = $\odot E$	1954, 7
	= 32' 34'',7
The moon's ecliptic long. by observation,	3 ^s 3° 33 1, 7
The true diff. of long. of $\odot$ and D accord- ing to the assumption,	27 18, 9
	= 1638'',9

D 's horary motion from $\odot$ 2113'', 3 : 1 hour = 3600'', ::
 1638'', 9 : 2792'' = 46' 32''. Subtract 46' 32'' from 11^h
 38' 23'', the time of the end of the eclipse at Chelsea, and
 the remainder 10^h 51' 51'', A. M. will be the time when the
 true

true ecliptic conjunction happened. This subtracted from $3^h 35' 53\frac{1}{4}''$, P. M. the time of the true ecliptic conjunction at Greenwich, leaves $4^h 44' 2\frac{1}{4}''$ for the difference of meridians between these two places. To this add $26''$, the difference of meridians between Cambridge and Chelsea; the sum, $4^h 44' 28\frac{1}{4}''$ will be the difference between Cambridge and Greenwich, by the observations of this eclipse.

Deductions from the observations of a transit of Mercury, November 5, 1743, for determining the difference of meridians between Paris* and Cambridge.

At Paris, November 5, 1743, a transit of Mercury was observed by

		1st. inter. contact.
		Apparent time.
Mr. Maraldi,	} At the Royal Observatory,	$8^h 40' 46''$
Mr. Caffini, jun.		$8 \ 40 \ 34$
The Abbe de la Caille, at College Mazarin,		$8 \ 40 \ 38$
Mr. Caffini, sen. at Thury,		$8 \ 40 \ 31$

The mean, $8 \ 40 \ 37\frac{1}{4}$

	2d. inter. contact.	2d. exter. contact.
Mr. Maraldi,	$1^h 10' 17''$	$1 \ 12 \ 18$
Mr. Caffini, jun.	$1 \ 10 \ 26$	$1 \ 12 \ 24$
The Abbe de la Caille,	$1 \ 10 \ 3$	$1 \ 11 \ 58$
Mr. le Monnier, jun. near } Port St. Honore,	$1 \ 9 \ 54\frac{1}{2}$	$1 \ 12 \ 2$

Mr.

* A bad state of the atmosphere prevented this transit from being observed at Greenwich.

Mr. Caffini, sen.

 $1^h. 10' 28''$

*

Mean, $1 \ 10 \ 13\frac{3}{5}$ $1 \ 12 \ 10\frac{1}{2}$

Hence it appears, that at the egress, Mercury was about $1' 57''$ in making his transit across the sun's limb, the half of which, viz. $58\frac{1}{2}''$, added to the time of the second internal contact, will give $1^h. 11' 12''$, P. M. for the time of the central contact, at the egress; and, subtracted from the time of the first internal contact, will give the central contact at the ingress $8^h. 39' 38\frac{3}{4}''$, A. M.

N. B. The place where Mr. Caffini, sen. observed is $6''$ in time east of the meridian of the Royal Observatory; the place where Mr. le Monnier, jun. observed, $2''$ west. The times observed by them are here adjusted to the meridian of the Observatory. The place where the Abbe de la Caille made his observations is so near to the meridian of the Royal Observatory, that the difference in time is imperceptible.

At $8^h. 39' 38\frac{3}{4}''$, A. M. apparent time, at the Royal Observatory of Paris.

The sun's longitude,	$7^s. 12^{\circ} 32' 57'', 205$
Mercury's geocentric ecliptic longitude,	$7 \ 12 \ 45 \ 5, 688$
Mercury's geocentric lat. south decreasing,	$10 \ 48, 165$
The sun's right ascension,	$220 \ 5 \ 40$
The right ascension of the mid-heaven,	$170 \ 0 \ 21$
Angle pPZ ,	$99 \ 59 \ 39$
	$= 80$

* Mr. Caffini, sen. was doubtful of the second external contact; it is therefore omitted.

	= 80° 0' 21"
Complement	9 59 39
Mercury's distance from the earth,	log. 4 829651
: The sun's distance from the earth,	log. 4 995787
:: The sun's horizontal parallax, 8",58	log. 0 933487
: Mercury's horizontal parallax, 12, 578	1 099620
Mercury's horizontal parallax from the sun,	3",998
The sun's semi-diameter,	16' 11, 7
Mercury's semi-diameter,	5, 1
The sun's horary motion,	2 30, 7
Mercury's geocen. horary mot. in the ecliptic retrog.	3 22, 12
Mercury's mot. upon ☉'s disc with respect to the eclip.	5 52, 82
Mercury's horary motion in latitude geocentric,	51, 7
Latitude of the Royal Observatory at Paris,	48° 50 14
Reduced to the center,	48 35 26
Complement = PZ	41 24 34

Hence

The altitude of the nonagesimal degree,	50 2 38
The longitude of the nonagesimal degree,	5 ^s 28 11 44
Angle Zp γ = B,	44 33 22
Mercury's parallax in longitude from the sun,	2, 151
Mercury's parallax in latitude from the sun,	2, 574
The sun's semi-diameter = ☉ γ	971, 7
Mercury's visible lat. from the sun's center = E γ	650, 739
The visi. diff. of long. of ☉'s and γ 's centers = ☉E,	721, 484
	= 12 37, 434
☉'s longitude,	7 12 32 57, 265
	Add

Add vifi. diff. long. of $\odot$'s & γ 's cent. γ being retro. $+ 12' 1'', 4$

	7 ^s . 12° 44' 58, 605
Mercury's parallax in longitude from the sun,	— 2, 151

	7 12 44 56, 454
--	-----------------

Mercury's true long. by observation,

The true diff. long. $\odot$'s & γ 's cen. by obs. at 8^h 39' 38 $\frac{3}{4}$ ', 11 59, 249

60

719, 249

N. B. The above references are to Plate I. Fig. I. and IV. γ being supposed changed for γ . The various processes are similar to those made in the foregoing solar eclipses.

At 1^h 11' 12'' the time of the central contact of γ at the egress.

The sun's longitude,	7 ^s . 12° 44' 19'', 258
Mercury's geocentric ecliptic longitude,	7 12 29 50, 909
Mercury's geocentric latitude south,	6 54, 174
The sun's right ascension,	220 16 58
The right ascension of the mid-heaven,	238 4 58
Angle pPZ	31 55 2
Complement	58 4 58

Hence

The altitude of the nonagesimal degree,	24 16 35
The longitude of the nonagesimal degree,	7 1 43 37
Angle $Zp\gamma = B$,	10 46 13
Mercury's parallax in longitude from the sun,	0, 307
	Mercury's

Mercury's parallax in latitude from the sun, $3''$, 647
 $\odot$ & as before, 97^1 , 782
 Mercury's visible lat. from the sun's center = E & 417 , 821
 The visible diff. of long. of $\odot$'s and $\&$'s centers = $\odot E$ 877, 284
 = 14^1 37, 284
 Mercury's true ecliptic long. by observation, 7^s 12° 29 41 , 667

Hence it appears, that Mercury's motion in geocentric longitude in the ecliptic, by observation, from his central contact at the ingress, to his central contact in the egress, was 15^1 $14''$, 787. According to the horary motion in the elements, from whence the calculations were made, it was 15^1 $14''$, 779. We may therefore take the motion given in the elements, as the true, and say, 5^1 $52''$, 82 = $352''$, 82 Mercury's horary motion upon the sun's disc with respect to the ecliptic : 1 hour = $3600''$:: $719''$, 249 the true difference of longitude of $\odot$'s and $\&$'s centers at the central contact at the ingress : $7339''$ = 2^h 2^1 $19''$. This added to 8^h 39^1 $38\frac{3}{4}''$, the time of Mercury's central contact at the ingress, will give 10^h 41^1 $57\frac{3}{4}''$, A. M. apparent time, for the true ecliptic conjunction, by observation.

The same transit was observed by Professor Winthrop,* at Cambridge, who saw the second internal contact at 8^h 17^1 $5''$,
 H A. M.

* Professor Winthrop, in a letter to Dr. Bliss, Astronomer Royal, dated 20th June, 1763, and published in vol. LIX, of the Philosophical Transactions, communicates his observations of this transit, with the express design of settling the longitude of Cambridge, by comparing them with the European ones; and he gives it as his opinion, that it might thereby be determined with more exactness, than by any observations that had been made use of, for that purpose.

He

A. M. apparent time, and the second external contact at $8^h 18' 58''$; which makes the contact of Mercury's center, at the egress, at $8^h 18' 1\frac{1}{2}''$, A. M.

Suppose the difference of meridians between Paris and Cambridge to be $4^h 53' 45''$, then it was $1^h 11' 46\frac{1}{2}''$, P. M. at Paris, when it was $8^h 18' 1\frac{1}{2}''$, A. M. at Cambridge.

Elements at $1^h 11' 46\frac{1}{2}''$, P. M. at Paris, answering to $8^h 18' 1\frac{1}{2}''$, A. M. at Cambridge.

The sun's longitude,	$7^s 12^{\circ} 44' 20'', 704$
Mercury's geocentric ecliptic longitude,	$7 12 29 48, 968$
Mercury's geocentric latitude south,	$6 53, 679$
The sun's right ascension,	$220 17 0$
The right ascension of the mid-heaven,	$164 47 22$
Angle pPZ ,	$105 12 38$
	$= 74 47 22$
	Complement $15 12 38$
PZ , as before,	$47 51 23$

Hence

The altitude of the nonagesimal degree,	$57 27 17$
The longitude of the nonagesimal degree,	$4 28 4 43$
Angle $Zp\gamma = B$,	$74 25 5$
Mercury's parallax in longitude from the sun,	$3, 246$
	Mercury's

He informs Dr. Bliss, that his clock was adjusted by correspondent altitudes of the bright star of Aries, taken the night before the transit, with a quadrant of two feet radius; and on the day of the transit, by correspondent altitudes of the sun; all which agreed within $5''$; and that he allowed for the difference of the sun's declination morning and afternoon.

Mercury's parallax in latitude from the sun, $2'', 154$

$\odot \gamma$, $971, 7$

Mercury's visi. lat. from the sun's center = $E\gamma$, $415, 833$

The visi. diff. of long. of $\odot$'s and γ 's centers = $\odot E$, $878, 227$

$= 14' 38, 227$

From the sun's longitude, $7^s. 12^{\circ} 44' 20, 701$

Subtract the visi. diff. of long. of $\odot$'s & γ 's centers, $14' 38, 227$

$7' 12' 29' 42, 474$

Subtract γ 's parallax in longitude from $\odot$, $3, 246$

Remains γ 's geocent. eclips. long. by observ. } $7' 12' 29' 39, 228$
accord. to the assumed diff. of meridians, }

The true diff. long. $\odot$'s & γ 's cent. by observa. } $14' 41, 473$
at $8^h. 18' 1\frac{1}{2}''$, A. M. }

60

$881, 473$

$352'', 82 : 3600'' :: 881'', 473 : 3994'' = 2^h. 29' 54''.$

Therefore,

From the time of γ 's central contact by } $8^h. 18' 1\frac{1}{2}''$, A. M.
observation at Cambridge, at the egress, }

Subtract $2' 29' 54$

Rem. the time of the true ecliptic conj. by obs. $5' 48' 7\frac{1}{2}''$, A. M.

The time of the true ecliptic conjunction } $10' 41' 57\frac{3}{4}''$, A. M.
at Paris by observation, }

Difference = the difference of meridians } $4' 53' 50\frac{1}{2}''$
between Paris and Cambridge, }

H 2

Subtract

Sub. the diff. of merid. betw. Paris & Greenwich, $\text{---} 9^{\circ} 16''$, A. M.

Remains the difference of meridians be- } $4^{\text{h}} 44' 34\frac{1}{2}''$
tween Greenwich and Cambridge,

The diff. by the observations of the solar } $4 44 29\frac{1}{2}$
eclipse of August 5, 1766,

Do. by the obs. of the sol. eclipse of June 24, 1778, } $4 44 28\frac{1}{4}$

The mean $4 44 30\frac{2}{3}$

Therefore, avoiding fractions, the difference } $4 44 31 \ddagger$
of meridians may be called

$\ddagger$ In a letter to the present Astronomer Royal, published in the volume of the Philosophical Transactions for 1781, I made the difference of meridians between Cambridge and Greenwich, by the solar eclipse of Aug. 1766, to be $4^{\text{h}} 44' 22''$; and by the transit of Venus of June, 1769, to be $4^{\text{h}} 44' 12''$; comparing Mr. Hitchins's observation of the internal contact only, with Dr. Winthorp's. The mean of these two results, viz. $4^{\text{h}} 44' 17''$, I gave as the true difference. But as the sun was low, when the observations of the transit were made at Greenwich, which caused an uncertainty attending them, not experienced where the altitude was considerable and the atmosphere clear, I have supposed it not expedient to make use of the result from this phenomenon, in the foregoing paper.

In making my deductions from the solar eclipse of 1766, in the above appendix, I have taken the mean between the time of the observations of the Astronomer Royal, and of his assistant; whereas, in the former calculations, I took those only of the Astronomer Royal. I have also used $42^{\circ} 23' 28''$, for the latitude of Cambridge, as determined by Professor Williams, instead of $42^{\circ} 25'$; and with these alterations, having carefully gone over the work anew, I have found the difference of meridians, from this eclipse, $4^{\text{h}} 44' 29\frac{1}{2}''$, instead of $4^{\text{h}} 44' 22''$.

The deductions from the transit of Mercury, and the solar eclipse of 1778, were not made, when the above letter was written.

I supposed it proper to add this note, to shew the reason of the difference between the result in this paper, and that in the letter published in the Philosophical Transactions.

I have been particular, in this appendix, in putting down the deductions from the observations which I have made use of, in settling the longitude of Cambridge from Greenwich, that any persons, who may meet with this paper, and are able to go thro' this kind of calculation, may see what stress is to be laid upon the determinations. If the deductions are right, the near agreement between the three results is a strong evidence of the goodness of the observations, and the dependence that may be made upon the mean result, for the difference of meridians between Greenwich and Cambridge; which, perhaps, is now ascertained to as great exactness as the difference between almost any two places, where terrestrial measurement has not been made use of.

J. W.



II. *A Memoir on the Latitude of the University at Cambridge : With Observations of the Variation and Dip of the Magnetic Needle.* By SAMUEL WILLIAMS, F. A. A. Hollis Professor of Mathematics and Natural Philosophy in the University.

THE latitude of Cambridge has generally been supposed to be $42^{\circ} 25'$ north. I cannot find how early, by what observer, or with what instruments it was determined. The earliest observations at Cambridge of which I can find any account, were those of eclipses made by Mr. Thomas Brattle, mentioned in *the Philosophical Transactions* for 1704, No. 292. p. 1630. The first of these was of a solar eclipse, June 12, 1694. And he there informs us, that in his calculations, the latitude of *Boston* was allowed to be $42^{\circ} 25'$. This has been universally received as the latitude ever since that time, and probably for many years before. As the ancient instruments belonging to the College were but small, I was desirous to examine this matter with all the accuracy I could. With this view I made the following observations. They were taken in the Philosophy-Chamber in Harvard-Hall, with an astronomical quadrant of two feet and an half radius, made by *Sissons*.

I. The

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1. The latitude of the University at Cambridge, computed from observations of the meridian altitude of the sun's upper limb.

Time.	Observation of the meridian altitude $\odot$'s upper limb.	Refraction.	$\odot$'s Semidiameter.	Parallax.	$\odot$'s Declination South.	Latitude of the University.
1782.						
Oct. 9	41° 24' 30"	1' 15"	16' 5", $\odot$	6"	6° 29' 35"	42° 23' 21"
10	41 1 39	1 16	16 5, 3	6	6 52 23	42 23 25,3
11	40 39 3	1 17	16 5, 5	6	7 15 5	42 23 20,5

By a mean of these observations the latitude is 42° 23' 22", 3

2. The latitude of the University computed from observations of the meridian altitude of stars near the Equator.

Observations of the meridian altitude of

Time.	δ In the wing of the <i>Eagle</i> .	π In the shoulder of <i>Antinous</i> .	θ In the hand of <i>Antinous</i> .	β In the shoulder of <i>Aquarius</i> .	α In the shoulder of <i>Aquarius</i> .	γ In the Arm of <i>Aquarius</i> .
1782.						
Oct. 9	50° 19' 9"	48° 5' 35"	0 11 11	0 1 11	0 11 11	0 1 11
12	50 19 51	48 5 57	46 10 34			
23		48 5 48	46 10 50			
Nov. 1			46 10 33			
3				41 7 8	46 15 45	45 9 35
4				41 6 53	46 15 33	45 9 20
5				41 6 53	46 15 34	45 9 18
Mean,	50 19 30	48 5 46,6	46 10 39	41 6 58	46 15 37,3	45 9 24,3

CALCULATIONS.

δ in the wing of the *Eagle*.

Mean of merid. altitudes taken Oct. 9, 12, 1782, 50° 19' 30"

Refraction by De la Caille's tables, — 55

True meridian altitude, 50 18 35

Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782, 2 41 55

Increase

Increase of declination in 9, 5 months,	+	5", 1
Aberration,	+	8, 6
Nutation,	—	8, 6
Apparent declination N. Oct. 11, 1782,		2° 42' 0, 1
Complement of the latitude,		47 36 34, 9
<i>Latitude,</i>		42 23 25, 1

π in the shoulder of *Antinous*,

Mean of merid. altitudes taken Oct. 9, 12, 28, 1782,	48	5	47
Refraction,	—	1	0
True meridian altitude,	48	4	47
Declin. N. Jan. 1, 1782, by <i>Connoi. des Temps</i> , 1782,	0	28	4
Increase of declination in 9, 5 months,	+	6, 7	
Aberration,	+	7, 5	
Nutation,	—	8, 3	
Apparent declination N. Oct. 16, 1782,	0	28	9, 9
Complement of the latitude,	47	36	37, 1
<i>Latitude,</i>	42	23	22, 9

θ in the hand of *Antinous*.

Mean of meridian altitudes taken Oct. 12, 23,	}	46	10	39
and November 1, 1782,				
Refraction,	—	1	4	
True meridian altitude,	46	9	35	
Declin. S. Jan. 1, 1782, by <i>Connoi. des Temps</i> , 1782,	1	26	57	
Decrease of declination in 9, 5 months,	—	7, 8		
Aberration,	—	6, 3		
Nutation,	+	8, 0		
Apparent declination S. Oct. 22, 1782,	1	26	50, 9	
Complement of the latitude,	47	36	25, 9	
<i>Latitude,</i>	42	23	34, 1	
				β in

β in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	41° 6' 58"
Refraction,	— 1 16
True meridian altitude,	41 5 42
Declin. S. Jan. 1, 1782, by <i>Connoi. des Temps</i> , 1782,	6 30 59
Decrease of declination in 10 months,	— 12, 5
Abberation,	— 3, 5
Nutation,	+ 6, 3
Apparent declination S. Nov. 4, 1782,	6 30 49, 3
Complement of the latitude,	47 36 31, 3
Latitude,	42 23 28, 7

α in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	46 15 37
Refraction,	— 1 14
True meridian altitude,	46 14 33
Declin. S. Jan. 1, 1782, by <i>Connoi. des Temps</i> , 1782,	1 22 5
Decrease of declination in 10 months,	— 14, 3
Aberration,	— 5, 4
Nutation,	+ 5, 2
Apparent declination S. Nov. 4, 1782,	1 21 50, 5
Complement of the latitude,	47 36 23, 5
Latitude,	42 23 36, 5

γ in the arm of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	45 9 24
Refraction,	— 1 16
True meridian altitude,	45 8 18
Declin. S. Jan. 1, 1782, by <i>Connoi. des Temps</i> , 1782,	2 28 33
Decrease of declination in 10 months,	— 14, 8
I Aberration,	

Aberration,	—	5"
Nutation,	+	4, 6
Apparent declination S. Nov. 4, 1782,		2° 28' 17, 8
Complement of the latitude,		47 36 35, 8
Latitude,		42 23 24, 2

The latitude by the meridian altitude of

δ in the <i>Eagle</i> ,	42 23 25, 1
π in <i>Antinous</i> ,	22, 9
θ in <i>Antinous</i> ,	34, 1
β in <i>Aquarius</i> ,	28, 7
α in <i>Aquarius</i> ,	36, 5
γ in <i>Aquarius</i> ,	24, 2

By a mean of these observations the latitude is 42 23 28, 6

3. The latitude of the University computed from observations of the meridian altitude of the pole-star.

Observations of the meridian altitude of the pole-star, below the pole.

1783. May 27	40° 33' 22"
28	40 33 25
29	40 33 35
June 5	40 33 22
Mean altitude,	40 33 26

CALCULATION.

Mean of merid. altitudes taken May 27, 28, 29, } 40 33 26
and June 1, 1783. Below the pole.

Refraction by De la Caille's tables, — 17

True meridian altitude, 40 32 9

Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782, 88 8 28

Increase

Increase of declination in one year,	+	19", 6
Increase of declination in 5 months,	+	8, 2
Aberration,	—	17, 0
Nutation,	+	2, 5
Apparent declination N. June 1, 1783,		88° 8' 41, 3
Distance from the pole,		1 51 18, 7
Latitude,		42 23 27, 7

From these calculations the latitude computed

1. From observations of the sun, is 42 23 22, 3
2. From observations of six stars near the Equator, 42 23 28, 6
3. From observations of the pole-star, 42 23 27, 7

In making the above observations I found it much easier to note the bisection of a star by the wire of the telescope, than to determine exactly the point of contact between the limb of the sun and the wire. On this account I esteem the observations of the meridian altitude of the stars more accurate than those of the sun : And therefore fix upon the mean of all the *sidereal observations* as the true

Latitude of Harvard-Hall at Cambridge, 42° 23' 28", 46

A R E M A R K.

The preceding observations will serve to determine the accuracy of the quadrant, as well as the latitude of the place. For this purpose I shall select the observations which were made on β in the shoulder of *Aquarius*, and those of the pole star.

Apparent declination of β S.	6° 30' 49, "3
Apparent declin. of the pole-star N.	88° 8' 41, "3
Distance from the pole.	1 51 18, 7
Below the pole at the time of observ.	1 51 18, 7

True meridian altitude of β ,	41° 5' 42"
True meridian altitude of the pole-star,	40 32 9
Sum of the declinations and altitudes,	179 59 59

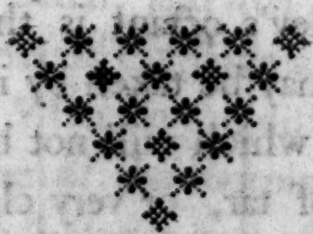
Hence it appears, that the sum of all the errors in the assumed declinations of these two stars, in the refraction, quadrant, and mean altitudes, do not amount to more than one second. It may therefore be presumed that the quadrant, observations, and elements of the calculations are very exact. The reason why the observations on β in *Aquarius* were chosen to examine the quadrant by, was because they are nearer the mean latitude than those of any other star, and therefore may be presumed to be the most correct.

II. Observations of the variation and dip of the magnetic needle, at the University in Cambridge.

Time.			Variation.	Dip.	Observer.
Year.	Mon.	D. H.	° ' W	° ' W	
1708,			9 0 W		Mr. Brattle,
1742,			8 0 W		Dr. Winthorp.
1757,			7 20 W		Dr. Winthorp.
1761,	Feb.	25,	7 14 W		Mr. Williams.
1763,			7 0 W		Dr. Winthorp.
1780,	Dec.	25, 1, P. M.	7 2 W	69 51	Mr. Williams.
1782,	June	21, 4, P. M.	6 46 W	69 41	Mr. Williams.
1783,	Dec.	23, 3, P. M.	6 52 W	69 41	Mr. Williams.

In the year 1782, Professor Sewall observed the diurnal variation of the magnetic needle during several months. At the

the same time I observed the diurnal alterations in the dipping needle. These observations are too numerous to be inserted here. In general, there is a remarkable regularity in the observations taken by the variation needle. The variation generally increases from seven or eight o'clock, A. M. till about two or three, P. M. From this time it generally decreases until seven or eight the next morning. The inclination or dip is subject to rather greater diurnal alterations than the variation; but they do not seem to be so regular in their changes. The least inclination I have ever observed was $68^{\circ} 21'$; the greatest $70^{\circ} 56'$.



III. *A Table of the Equations to equal Altitudes, for the Latitude of the University of Cambridge, $42^{\circ}23'28''$ N. with an Account of it's Construction and Use.* By the Reverend JOSEPH WILLARD, President of the University.

THE regulation of a clock, which is made use of for astronomical purposes, is of the utmost importance. Unless it's going is accurately ascertained, the observations made by it, however excellent in other respects, can be of no use. Every thing, therefore, which tends to facilitate it's regulation, is worthy of attention.

The best method to ascertain the going of a clock, where a person has not a transit instrument fixed in the meridian, is by equal altitudes of the sun, taken by some instrument adapted to the purpose. Hadley's octant is the most easily obtained; and double altitudes may be taken by it, by reflection from a bowl of some liquid, which will not be easily put into motion by the air. The oil of tar, or very clean molasses will answer the purpose well.

The method is, to take the altitude of the sun's upper or lower limb, or both, in the morning as far from noon as may be convenient, and note the time by the clock to a second. The time must be noted in the afternoon, when the altitude is the same. Then, add half the interval between the two observations, to the time of the morning observation, which will give the time by the clock, nearly, when the sun's center passed the

the meridian. This would be the apparent noon exactly, if the sun did not alter his declination : But as this is constantly varying, a small equation, arising from the change of declination between the forenoon and afternoon observations, must be applied to the time of noon thus found, except at the solstices, when the variation is too small to make any equation necessary.

ILLUSTRATION.

In Plate I. Fig. VI. let EPQL be the hour circle of six o'clock, and ECQ a portion of the Equator. Let P be the north-pole, L the south ; and PZL the meridian of some place. Let the arc PZ mark the latitude of a given place : Then, the point Z will be it's zenith ; and the arc HOR will be a portion of the horizon, O being 90° distant from Z. Let the arc mxg mark the sun's declination, in the morning, at a time when his altitude is taken, and avn the declination in the afternoon, when his altitude is the same as in the morning observation. Let the angle $ZP\odot$ be the distance of the sun from the meridian, at the time of the morning observation = the half interval between the forenoon and afternoon observations, nearly ; then side PZ will be the co-latitude of the place, the side $P\odot$ the sun's co-declination, and the side $Z\odot$ the sun's co-altitude or zenith distance. Let the co-altitude $Z\odot$ be set off from Z to r , a point in the arc of the sun's declination, at the time of the forenoon observation, and through r draw the arc $P\hat{r}L$. Let $Z\odot$ also be set off from Z to S, a point in the arc of the sun's declination, at the time of the afternoon observation, and through S draw the arc PSL. Then, it will be evident,

dent, that when the sun has the same zenith distance in the afternoon observation that he had in the forenoon, he will be further distant from the meridian by the space pq , measured upon the Equator, equal to the angle pPq . Bisect the angle $\odot PS$, and draw the pricked arc PbL , (the same as adding the half interval to the time of the forenoon observation) which shews the mean noon; but it is as much after the apparent noon, or the true time of the sun's passing the meridian, as the space Cb upon the Equator, which is equal to half pq . The time answering to Cb , therefore, must, in this case, be subtracted from the mean noon, which will reduce it to the meridian PCL , or, which is the same thing, give the true time when the sun passed the meridian, by the clock. This equation, Cb , may easily be found trigonometrically, by the triangles $P\odot Z$ and PSZ .

EXAMPLE.

At Cambridge, latitude $42^{\circ} 23' 28''$ N. suppose the altitude of the sun taken April 2, 1783, at $8^h 40'$, A. M. i. e. at $3^h 20'$, or 50° , from the meridian, and the corresponding altitude taken in the afternoon; required the equation to the corresponding altitudes?

April 2, 1783, at $8^h 40'$, A. M. } $5^{\circ} 1' 00''$ Com. = $P\odot 84^{\circ} 59' 0''$	$\odot$'s declination,
At $3^h 20'$, P. M. ditto, 5 7 22 Com. = $PS 84 52 38$	
Co-latitude, = $PZ 47 36 32$	
Angle $ZP\odot = 3^h 20'$ = $50 0 0$	

In

In the triangle $ZP\odot$, given sides PZ and $P\odot$, and the included angle $ZP\odot$, to find side $Z\odot$ the co-altitude or zenith distance of the sun at the time of observation? Zi is perpendicular to $P\odot$.

Radius,

: Sine co-angle $ZP\odot$ $40^{\circ} 0' 0''$ 9 8080675

:: Tangent PZ $47 36 32$ 10 0396048

: Tangent segment Pi $35 9 6$ 9 8476723

$P\odot$ $84 59 0$

Diff. = segment $\odot i$ $49 49 54$

Sine Co- Pi $54 50 54$ 9 9125573

: Sine Co- $\odot i$ $40 10 6$ 9 8095836

:: Sine Co- PZ $42 23 28$ 9 8287809

: Sine Co- $Z\odot$ $32 7 55$ 9 7258072

$Z\odot = ZS$ $57 52 5$

In the triangle ZPS are given the three sides to find angle ZPS .

PZ $47 36 32$

PS $84 52 38$

$ZS = Z\odot$ $57 52 5$

Sum of sides $190 21 15$

$\frac{1}{2}$ sum $95 10 37, 5$

$\frac{1}{2}$ sum - PZ $47 34 5, 5$

$\frac{1}{2}$ sum - PS $10 17 59, 5$

K

PZ

PZ	Sine $47^{\circ} 36' 42''$	9	8683857
x PS	Sine $84^{\circ} 52' 38''$	9	9982618
		19	8666475

: Radius square,

20

:: $\frac{1}{2}$ sum of sides—PZ = Sine	47 34 5, 5	9	8681039
x $\frac{1}{2}$ sum of sides—PS = Sine	10 17 59, 5	9	2523671

: Sine of square of $\frac{1}{2} \angle$ ZPS

2 | 19 2538235

Sine of $\frac{1}{2} \angle$ ZPS

25	3	33, 7	9	6769117
x 2				

Angle ZPS

50 7 7, 4

Subtract ZP $\odot$

50

Remains space pq , or angle pPq

7 7, 4

x 4

Reduced to time,

28' 29", 6

The $\frac{1}{2}$ of which is Cb = the equa-
tion to the equal altitudes,

14	14,	8
----	-----	---

This method is accurate, but tedious; and to shorten the work, formulas have been invented. One deduced by Mr. William Wales from art. 256 of Simpson's Fluxions is, perhaps, as easy and concise as any. It is divided into two parts. The first is composed of the change in the sun's declination, during half the interval between the observations, multiplied by the co-secant of the sun's horary angle at the times of the observations,

tions, multiplied again by the tangent of the geographical latitude. The second part consists of the said change in the declination, multiplied by the tangent of the sun's declination, multiplied again by the co-tangent of the sun's horary angle. When the sun's declination is north, this second part of the equation is to be subtracted from the first; but when it is south, it is to be added to it; and the difference or sum will be the equation to the equal altitudes: Which equation is additive, when the sun is declining southward; i. e. when the declination is north decreasing or south increasing; but when the contrary, it is subtractive.

These rules are to be observed, when the latitude is north: They must be inverted, when it is south.

The exactness of this formula will appear, by making use of the foregoing example.

Whole change in declination $6' 22''$. Half do. $3' 11''$ added to $5^\circ 1' 0''$, the declination at the time of the morning observation, gives $5^\circ 4' 11''$ for $\odot$'s declination at noon.

Half change of declin.	$3' 11'' = 191''$	2 2810334
x Secant of co-hour angle,	$40^\circ 0' 0''$	10 1157460
x Tangent of the latitude,	$42 23 28$	9 9603952
First part of the equation,	227, 6	2 3571746

K 2

Half

Half change declination	191"	2 2810334
x Tangent declination,	5° 4' 11"	8 9479970
x Tangent co-hour angle,	40 0 0	9 9238135
Second part of the equation,	14, 2	1 1528439
Which subtracted from the first part,	227, 6	
Leaves the equat. to the equal altitudes,	213, 4	
	= 3 33, 4	
	x 4	
The equation in time,	14" 13"', 6	

By this formula was the following table calculated ; but it is to be observed, that the sun's longitude, instead of the declination answering to it, is put down for the argument, as being the most convenient.

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A TABLE of the EQUATIONS to equal Altitudes. For Lat. $42^{\circ} 23' 28''$ N.

Half Interval between the Observations.

's lon- tude.	H. M. II 0	H. M. II 10	H. M. II 20	H. M. II 30	H. M. II 40	H. M. II 50	H. M. III 0	H. M. III 10	H. M. III 20	H. M. III 30	H. M. III 40	H. M. III 50	H. M. IV 0	H. M. IV 10	H. M. IV 20	H. M. IV 30
D.	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13	17.33
5	13.52	14. 0	14. 9	14.18	14.27	14.37	14.47	14.59	15.12	15.26	15.40	15.56	16.13	16.31	16.51	17.12
10	13.13	13.22	13.31	13.40	13.50	14. 0	14.11	14.24	14.39	14.54	15. 9	15.25	15.43	16. 2	16.23	16.44
15	12.31	12.41	12.51	13. 1	13.11	13.21	13.32	13.46	14. 1	14.17	14.32	14.49	15. 7	15.26	15.47	16.10
20	11.45	11.55	12. 5	12.15	12.26	12.37	12.49	13. 3	13.18	13.33	13.50	14. 7	14.26	14.46	15. 8	15.30
25	10.56	11. 6	11.16	11.27	11.38	11.49	12. 2	12.16	12.31	12.46	13. 3	13.21	13.40	14. 0	14.23	14.46
— 0	10. 6	10.16	10.26	10.36	10.47	10.59	11.12	11.25	11.40	11.55	12.12	12.30	12.50	13.11	13.33	14.56
5	9. 4	9.23	9.34	9.44	9.55	10. 7	10.19	10.32	10.48	11. 3	11.20	11.38	11.58	12.19	12.40	13. 2
10	8.21	8.30	8.40	8.50	9. 1	9.12	9.25	9.39	9.54	10. 8	10.25	10.42	11. 1	11.21	11.41	12. 4
15	7.27	7.36	7.46	7.55	8. 6	8.17	8.29	8.42	8.56	9.10	9.26	9.44	10. 3	10.22	10.42	11. 3
20	6.35	6.43	6.52	7. 1	7.11	7.21	7.33	7.45	7.59	8.13	8.28	8.44	9. 2	9.20	9.39	9.58
25	5.43	5.50	5.58	6. 7	6.16	6.26	6.37	6.49	7. 1	7.13	7.27	7.41	7.57	8.14	8.32	8.50
I— 0	4.52	4.58	5. 5	5.12	5.20	5.29	5.39	5.50	6. 2	6.13	6.25	6.38	6.52	7. 7	7.23	7.40
5	4. 0	4. 6	4.13	4.20	4.27	4.35	4.43	4.52	5. 2	5.11	5.21	5.32	5.44	5.57	6.11	6.26
10	3.10	3.15	3.21	3.27	3.33	3.39	3.46	3.53	4. 0	4. 7	4.16	4.26	4.36	4.47	4.49	5.12
15	2.22	2.25	2.29	2.33	2.38	2.43	2.48	2.53	2.59	3. 5	3.12	3.19	3.27	3.36	3.46	3.55
20	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
25	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
II+ 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0
5	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
10	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
15	2.22	2.25	2.29	2.33	2.37	2.42	2.47	2.52	2.59	3. 5	3.12	3.19	3.27	3.36	3.45	3.55
20	3. 9	3.14	3.19	3.24	3.30	3.37	3.44	3.51	3.59	4. 6	4.15	4.26	4.36	4.47	4.49	5.11
25	3.58	4. 4	4.11	4.18	4.25	4.33	4.41	4.49	4.58	5. 7	5.18	5.30	5.42	5.55	6. 9	6.24
IV+ 0	4.50	4.57	5. 4	5.11	5.19	5.28	5.38	5.48	5.59	6.10	6.22	6.36	6.50	7. 6	7.20	7.36
5	5.43	5.50	5.58	6. 6	6.15	6.24	6.35	6.46	6.59	7.11	7.25	7.40	7.56	8.13	8.31	8.49
10	6.34	6.42	6.50	6.59	7. 9	7.20	7.31	7.43	7.56	8. 9	8.24	8.40	8.58	9.16	9.35	9.56
15	7.26	7.34	7.43	7.52	8. 2	8.13	8.25	8.38	8.52	9. 6	9.22	9.39	9.57	10.16	10.37	10.59
20	8.19	8.27	8.36	8.46	8.57	9. 9	9.22	9.36	9.50	10. 4	10.21	10.38	10.56	11.16	11.38	11.59
25	9. 9	9.18	9.28	9.39	9.50	10. 1	10.13	10.27	10.42	10.57	11.14	11.31	11.50	12.11	12.33	12.56
V+ 0	10. 1	10.10	10.20	10.30	10.41	10.53	11. 6	11.20	11.35	11.49	12. 6	12.24	12.43	13. 3	13.25	13.48
5	10.51	11. 0	11. 9	11.19	11.30	11.42	11.55	12. 9	12.24	12.39	13.56	13.14	13.33	13.53	14.15	14.38
10	11.39	11.48	11.57	12. 7	12.18	12.29	12.41	12.55	13.10	13.24	12.56	13.59	14.18	14.38	15. 0	15.22
15	12.24	12.33	12.42	12.52	13. 3	13.14	13.25	13.38	13.52	14. 8	14.23	14.40	14.58	15.17	15.38	15.59
20	13. 8	13.15	13.23	13.32	13.42	13.53	14. 4	14.16	14.30	14.45	14.59	15.15	15.32	15.51	16.12	16.33
25	13.43	13.51	14. 0	14.10	14.20	14.30	14.40	14.51	15. 4	15.18	15.31	15.46	16. 2	16.20	16.40	17. 1
VI+ 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3	17.22

A TABLE of the EQUATIONS to equal Altitudes. For Lat. $42^{\circ} 23' 28''$ N

Half Interval between the Observations.

☉'s longitude.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
	II 0	II 10	II 20	II 30	II 40	II 50	III 0	III 10	III 20	III 30	III 40	III 50	IV 0	IV 10	IV 20	IV 30
S. D.	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
VI + 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3	17.2
5	14.44	14.51	14.58	15. 6	15.15	15.24	15.33	15.43	15.54	16. 0	16.18	16.32	16.47	17. 3	17.20	17.3
10	15. 6	15.12	15.18	15.25	15.33	15.42	15.50	16. 0	16.10	16.21	16.32	16.45	16.59	17.13	17.28	17.4
15	15.21	15.27	15.33	15.39	15.45	15.52	15.59	16. 8	16.18	16.29	16.39	16.51	17. 4	17.17	17.31	
20	15.29	15.33	15.38	15.44	15.50	15.56	16. 2	16.11	16.20	16.30	16.39	16.49	17. 0	17.12	17.25	
25	15.28	15.32	15.37	15.42	15.47	15.53	15.59	16. 5	16.12	16.20	16.28	16.37	16.47	16.57		
VII + 0	15.17	15.21	15.25	15.29	15.36	15.39	15.43	15.49	15.56	16. 3	16.10	16.18	16.26	16.36		
5	14.58	15. 0	15. 3	15. 6	15.10	15.15	15.19	15.24	15.30	15.36	15.41	15.48	15.56			
10	14.30	14.32	14.34	14.36	14.39	14.42	14.45	14.50	14.55	15. 0	15. 4	15.10	15.16			
15	13.46	13.47	13.48	13.50	13.52	13.55	13.58	14. 2	14. 7	14.12	14.16	14.21				
20	12.52	12.53	12.55	12.57	12.59	13. 2	13. 4	13. 7	13.10	13.13	13.15					
25	11.47	11.48	11.49	11.50	11.51	11.53	11.56	11.59	12. 2	12. 5						
VIII + 0	10.31	10.31	10.32	10.33	10.34	10.36	10.38	10.40	10.43							
5	9. 4	9. 4	9. 5	9. 6	9. 7	9. 8	9. 9	9.10	9.12							
10	7.29	7.29	7.30	7.30	7.31	7.31	7.32	7.32	7.33							
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47							
20	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53							
25	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0							
IX — 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0							
5	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0							
10	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53							
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47							
20	7.30	7.30	7.31	7.31	7.32	7.32	7.33	7.33	7.34							
25	9. 6	9. 6	9. 7	9. 8	9. 9	9.10	9.11	9.12	9.14							
X — 0	10.33	10.35	10.35	10.36	10.37	10.39	10.41	10.43	10.45							
5	11.51	11.52	11.53	11.54	11.56	11.58	12. 0	12. 3	12. 6	12. 9						
10	12.58	12.59	13. 0	13. 1	13. 2	13. 4	13. 5	13. 8	13.12	13.17	13.21					
15	13.53	13.54	13.55	13.56	13.58	14. 0	14. 2	14. 6	14.11	14.16	14.20	14.26				
20	14.34	14.36	14.38	14.41	14.45	14.49	14.52	14.56	15. 0	15. 5	15. 9	15.15	15.22			
25	15. 5	15. 7	15.10	15.13	15.17	15.22	15.26	15.31	15.37	15.43	15.49	15.56	16. 4			
XI — 0	15.25	15.29	15.33	15.37	15.42	15.48	15.53	15.59	16. 6	16.13	16.19	16.27	16.36	16.45		
5	15.35	15.39	15.44	15.49	15.55	16. 1	16. 7	16.15	16.23	16.31	16.35	16.46	16.48	17. 8		
10	15.36	15.41	15.46	15.52	15.59	16. 6	16.13	16.52	16.31	16.41	16.46	16.58	17. 1	17.22	17.34	
15	15.29	15.35	15.41	15.47	15.54	16. 2	16.10	16.19	16.29	16.39	16.49	17. 1	17.14	17.27	17.41	
20	15.14	15.21	15.28	15.36	15.46	15.52	16. 0	16. 9	16.19	16.30	16.41	16.54	17. 8	17.23	17.39	
25	14.53	15. 0	15. 8	15.16	15.25	15.34	15.42	15.52	16. 3	16.15	16.27	16.41	16.56	17.12	17.29	
0 — 0	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13	

The use of the foregoing table will appear easy by an example.

April 12, 1782, the following corresponding double altitudes of the sun were taken at Cambridge with Hadley's octant.

	D. Alt.	Foren. Obs.	Afternoon.	Interval.	$\frac{1}{2}$ Interval.	Mean Noon.
Sun's up-	54° 00'	7 ^h 56' 27"	4 ^h 11' 0"	8 ^h 14' 33"	4 ^h 7' 16 $\frac{1}{2}$ "	12 ^h 3 ^m 43 ^s 30 ^m
per limb.	58 00	8 7 33	3 59 50	7 52 17	3 56 8 $\frac{1}{2}$	12 3 41 30
Sun's low-	59 20	8 14 18	3 53 0	7 38 42	3 49 21	12 3 39 00
er limb.	61 20	8 20 3	3 47 22	7 27 19	3 43 39	12 3 42 30
Mean noon by the clock by the above observations,						12 3 41 37
Equation by the table for change of declina. during the $\frac{1}{2}$ interval,						—13 49
Apparent time by clock when ☉'s center passed the meridian,						12 3 27 48

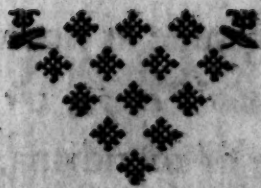
Hence, we find that the clock was 3' 27" 48" too fast for apparent time.

The mean $\frac{1}{2}$ interval to these corresponding altitudes is 3^h 54' 6". The sun's longitude at noon, on the above day, was, at Paris, by *Connoissance des Temps*, 0^s. 22° 40'; therefore, allowing for the difference of meridians, it was at Cambridge, 0^s. 22° 52'. Hence, by taking the proportion in the table between the equations for the $\frac{1}{2}$ interval 3^h. 50' and 4^h. 0', and for the longitudes 0^s. 20° and 0^s. 25°, for the $\frac{1}{2}$ interval 3^h. 54' 6" and the longitude 0^s. 22° 52', we shall find 13' 49", as in this example.

The

The table of equations to equal altitudes is calculated for latitude $42^{\circ} 23' 28''$; but by adding or subtracting the following small equations, or proportional parts of them, the general equations may be found, as far as two degrees in latitude more or two degrees less. These small equations are put down with their sign for the sun's longitudes, the half intervals and the latitudes to which they are calculated; and they need no explanation.

			$\frac{1}{2}$ Intervals.			$\frac{1}{2}$ Intervals.		
			2h. 4h. 30'			2h. 4h. 30'		
S. o	S. o	S. o	Lat. 41 23 28 N	Equ.	— 30 — 36	Lat. 40 23 28	Equ.	— 59 — 11
☉'s long. o	o & VI. o	Lat. 43 23 28			+ 31 + 37	Lat. 44 23 28		+ 1 2 + 1 17
☉'s long. I. 15	IV. 15	Lat. 41 23 28			— 21 — 26	Lat. 40 23 28		— 42 — 51
VII. 15 & X. 15		Lat. 43 23 28			+ 22 + 27	Lat. 44 23 28		+ 45 + 55



IV. *Astronomical Observations, made in the State of Massachusetts. By Professor WILLIAMS.*

Observations of the eclipses of the sun and moon, in the years 1761, and 1764; and from 1770 to 1784.

1. An observation of a lunar eclipse, November 12, 1761, at *Waltham.*

THE weather was so cloudy that I could only make the following observations of this eclipse.—

	Temp. app.
The shadow reached <i>Kepler,</i>	16 ^h . 59' 0"
<i>Mare Vaporum,</i>	17 7 40
<i>Tycho,</i>	14 25
<i>Menelaus,</i>	17 28
<i>Mare Crisum,</i>	28 11
Total immersion,	45 10

2. An observation of a lunar eclipse, March 17, 1764, at *Waltham.*

The moon rose behind a cloud that lay along the horizon, but soon began to appear: About 6^h. 10' I saw her considerably eclipsed: *Tycho* was then covered.

The shadow reached <i>Nectaris,</i>	6 ^h . 30'
<i>Copernicus,</i>	32
<i>Mare Vaporum,</i>	43
<i>Menelaus,</i>	55
<i>L</i>	<i>Archimedes,</i>

The shadow reached <i>Archimedes</i> ,	56'
<i>Mare Crisium</i> ,	7 ^h 3
covers <i>Mare Crisium</i> ,	17
<i>Tycho</i> begins to appear,	8 12
leaves <i>Mare Crisium</i> ,	21
End of the eclipse,	39 54"

These observations were made with a reflecting telescope about four feet in length : And the clock was adjusted by a meridian line, and corresponding altitudes of the sun.

3. An observation of a solar eclipse, November 6, 1771, at *Bradford*.

The beginning of this eclipse could not be observed, the weather being cloudy. At 1^h 36' 42", it was evident that the eclipse was begun. The clouds prevented also any observation of the quantity of the eclipse : But I had a good observation of the end, which was at 3^h 47' 2" apparent time.

4. An observation of a lunar eclipse, April 6, 1773, at *Bradford*.

	Temp. app.
Beginning of the eclipse,	14 ^h 32' 38"
The shadow reaches <i>Grimaldus</i> ,	40 43
<i>Mare Humorum</i> ,	41 53
covers <i>Mare Humorum</i> ,	47 38
reaches <i>Tycho</i> ,	52 23
<i>Kepler</i> ,	15 1 28
<i>Copernicus</i> ,	11 20
<i>Mare Tranquillitatis</i> ,	27 13
<i>Mare Fecunditatis</i> ,	32 54
	<i>Mare</i>

The shadow reaches <i>Mare Serenitatis</i> ,	42' 15"
<i>Mare Crisum</i> ,	58 8
leaves <i>Mare Crisum</i> ,	16 ^h 43 23
<i>Mare Humorum</i> ,	45 23
<i>Mare Tranquillitatis</i> ,	52 25
<i>Tycho</i> ,	59 38
End of the eclipse,	17 20 10

The last observation was attended with some uncertainty ;— the moon being near the horizon, and the day-light far advanced.

5. An observation of a lunar eclipse, July 30, 1776, at *Bradford*.

This eclipse was total : But the beginning of it, and the beginning of total darkness were invisible at *Bradford*, both happening before the moon rose. I was in hopes to have seen the end of total darkness, but was prevented by clouds. At 8^h 30' the sky became perfectly clear, so that I had a good observation of the end of the eclipse, which was at 9^h 2' 44".

6. An observation of a solar eclipse, June 24, 1778, at *Bradford*.

The beginning of this eclipse could not be observed, the sun being wholly covered with clouds. At 10^h 8' they broke away : And though often interrupted afterwards, I was able to note the following phenomena.

About 10^h 16', the horns of the sun were observed to have an equal altitude, being in a line parallel to the horizon. At 10^h 23' the lucid parts of the sun amounted to 2' 45"; whence,

as the sun's apparent diameter was $31' 34''$, the eclipsed parts were $28' 49''$, or 10 digits and 57 minutes. This was very near the time of the greatest obscuration: But whether it was exactly so I could not determine, the sun being obscured just before and after this observation. At $10^h 25'$ a large spot emerged from the shadow. At $10^h 59'$ four other large spots were wholly within the lucid part. At the end of the eclipse the sky was become clear, and by a good observation I found this to be at $11^h 38' 16''$ apparent time.

During the eclipse, there was a very sensible alteration in the state of the *air*. A chill, and a damp were very generally felt. The mercury in the thermometer at $9^h 4'$, just before the eclipse began, was at $67^{\circ} \frac{1}{2}$. At $10^h 20'$, it fell to 66° . At the end of the eclipse it rose to 73° ; and at noon it was at $74^{\circ} \frac{1}{2}$.

As the time of the greatest obscuration came on, that part of the sky, which was free from clouds, changed from an azure blue, to a more dark and dusky colour: And the dew fell so fast as to wet the paper we were using to a considerable degree.

As this eclipse was *total* in some of the *southern states*, I was very desirous to have it carefully observed in several places, in hope that a sufficient number of observations might be collected to determine the exact path and limits of the shadow: And it was with much regret that I found myself prevented by the weather from making a more compleat observation.

7. An observation of a lunar eclipse, December 3, 1778, at
Bradford.

Beginning

	Temp. app.
Beginning of the eclipse,	11 ^h . 41' 14 ^u
The shadow reaches <i>Mare Serenitatis</i> ,	12 6 6
<i>Copernicus</i> ,	13 53
<i>Mare Tranquillitatis</i> ,	23 12
<i>Mare Crisum</i> ,	28 15
leaves <i>Mare Imbrium</i> ,	13 47 0
<i>Mare Serenitatis</i> ,	54 0
<i>Mare Crisum</i> ,	59 30
End of the eclipse,	14 5 20

These observations were made in a very favourable state of the air.

8. An observation of a lunar eclipse, and an emerfion of Jupiter's fecond fatellite, May 29, 1779, at *Bradford*.

The emerfion of the fatellite was at	8 58 13
Beginning of the eclipse,	10 15 41
The shadow touches <i>Tycho</i> ,	35 15
<i>Copernicus</i> ,	40 35
<i>Mare Serenitatis</i> ,	11 0 6
<i>Mare Crisum</i> ,	18 15
Beginning of total darknefs,	28 39
End of total darknefs,	12 50 41
The shadow leaves <i>Tycho</i> ,	13 27 7
<i>Mare Serenitatis</i> ,	38 57
<i>Mare Crisum</i> ,	54 49
End of the eclipse,	14 3 51

During

During the whole time of this eclipse, the weather was very favourable for observation. All the observations made at *Bradford*, were taken with a reflector made by *Nairne*, magnifying about 55 times. The times were shewn by a good clock, carefully adjusted by equal altitudes of the sun, the day before and the day after the eclipse.

9. Observations of a solar eclipse, October 27, 1780, made on the east side of *Long-Island*, in *Penobscot-Bay*.

A total eclipse of the sun is a curious and uncommon phenomenon. From the principles of astronomy it is certain that a central eclipse will happen, in some part of the earth, in the course of every year : But it is but seldom that a total eclipse of the sun is seen in any particular place. A favourable opportunity presenting for viewing one of these eclipses on October 27, 1780, the American Academy of Arts and Sciences, and the University at Cambridge, were desirous to have it properly observed in the eastern parts of the State, where, by calculation, it was expected it would be total. With this view they solicited the government of the Commonwealth, that a vessel might be prepared to convey proper observers to *Penobscot-Bay* ; and that application might be made to the officer who commanded the *British* garrison there, for leave to take a situation convenient for this purpose.

Though involved in all the calamities and distresses of a severe war, the government discovered all the attention and readiness to promote the cause of science, which could have been expected in the most peaceable and prosperous times ; and passed a resolve, directing the Board of War to fit out the
Lincoln

Lincoln galley to convey me to *Penobscot*, or any other port at the eastward, with such assistants as I should judge necessary.

Accordingly, I embarked October 9, with Mr. Stephen Sewall, Professor of the Oriental Languages, James Winthrop, Esq; Librarian, Fortesque Vernon, A. B. and Mess^{rs}. Atkins, Davis, Hall, Dawson, Rensselaer, and King, Students in the University. We took with us an excellent clock, an astronomical quadrant of $2\frac{1}{2}$ feet radius, made by *Sissons*, several telescopes, and such other apparatus as were necessary.

On the 17th we arrived in *Penobscot-Bay*. The vessel was directed to come to anchor in a cove on the east side of *Long-Island*. After several attempts to find a better situation for observations, we fixed on this place as the most convenient we had reason to expect :* And on the 19th we put our instruments on shore, set up the clock and quadrant in a building facing towards the south, near the house of Mr. *Shubael Williams*, where the following observations were made.

OCTOBER 20.

Corresponding altitudes of the sun taken with a reflector fitted with vertical and horizontal wires.

Time

* As the officer who commanded at *Penobscot*, in his answer to the application of the government, had limited us to a time wholly inadequate to our purpose, from the 25th to the 30th of October, we were obliged to make a second application for leave to enter *Penobscot-Bay*. Leave was granted, but with a positive order to have no communication with any of the inhabitants, and to depart on the 28th, the day after the eclipse. Being thus retarded and embarrassed by military orders, and allowed no time after the eclipse to make any observations, it became necessary to set up our apparatus and begin our observations without any further loss of time. In the course of which, we received every kind of assistance from Capt. *Henry Mowatt*, of the *Albany*, which it was in his power to give.

Time by the clock.

	Eastern az.	Western az.	Meridian.
	8 ^h . 15' 44"	3 ^h . 54' 43"	12 ^h . 5' 13",5
	21 58	48 28	13
	28 48	41 34	11
	31 30	58 57	13, 5
Mean,			12 5 12, 75
Equation of altitudes,			+ 17, 50
☉'s center on the meridian,			12 5 30, 25
Clock too fast,			5 30, 25
Meridian altitude of the sun's upper limb, taken with the astronomical quadrant,			35° 15' 45"

OCTOBER 21.

Corresponding altitudes of the sun taken with a reflector.

Time by the clock.

	Eastern az.	Western az.	Meridian.
	8 ^h . 15' 11"	3 ^h . 58' 20"	12 ^h . 6' 45",5
	18 45	54 46	45, 5
	21 35	51 52	43, 5
	28 28	45 5	46, 5
	32 7	41 23	45
	35 17	38 12	44, 5
	45 53	27 36	44, 5
Mean,			12 6 45
Equation of altitudes,			+ 17, 5
☉'s center on the meridian,			12 7 2, 5
Clock gains in 24 hours,			1 32, 25

OCTOBER

OCTOBER 22.

Thick fog all day. No astronomical observations. At 8^h 15', A. M. I put the clock back 15', and lengthened the pendulum.

OCTOBER 23.

Thick fog all day. No astronomical observations.

OCTOBER 24.

Corresponding altitudes of the sun, taken with the quadrant.

Time by the clock.

Eastern az.	Western az.	Meridian.
8 ^h . 1' 47"	3 ^h . 44' 58"	11 ^h . 53' 22".5
4 55	41 52	23, 5
7 58	38 54	26
11 31	35 23	27
14 57	31 51	24

Mean, 11 53 24.60
 Equation of altitudes, + 16.75
 ☉'s center on the meridian, 11 53 41.35
 Clock too slow, 6 58.65

Meridian altitude of the sun's upper limb, 33° 51' 43"

In the night I observed the meridian altitude of

Rigel,	37 16 15
Sirius,	29 19 0
Procyon,	51 30 26

OCTOBER 25.

Corresponding altitudes of the sun, taken with the quadrant.

M

Time

Time by the clock.

	Eastern az.	Western az.	Meridian.
8 ^h .	31' 17"	3 ^h . 17' 19"	11 ^h . 54' 18"
	35 4	13 31	17, 5
	36 43	11 53	18
	38 16	10 20	18
	42 4	6 28	16
	45 16	3 16	16
	46 0	2 33	16, 5
	47 38	0 53	15, 5
	49 16	2 59 11	13, 5
	57 16	51 8	12
	59 3	49 25	14
9	0 39	47 47	13

Mean,	11 54 15, 66
Equation of altitudes,	+ 16, 63
☉'s center on the meridian,	11 54 32, 29
Clock too slow,	5 27, 71
Clock gains in 24 hours,	50, 94

Meridian altitude of the sun's upper limb,	33° 31' 4"
In the night I observed the meridian altitude of	
<i>Rigel,</i>	37 16 15
<i>Sirius,</i>	29 19 6
<i>Procyon,</i>	51 30 30

OCTOBER 26.

Corresponding altitudes of the sun, taken with the quadrant.

Time

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Time by the clock.

Eastern az.	Western az.	Meridian.
8h. 30' 56"	3h. 19' 13"	11h. 55' 4".5
32 31	17 41	6
34 3	16 5	4
34 45	15 26	5. 5
36 25	13 46	5. 5
37 56	12 13	4. 5

Mean,

Equation of altitudes,

☉'s center on the meridian,

Clock too slow,

Clock gains in 24 hours,

11 55 5

+ 16. 53

11 55 21. 53

4 38. 47

49. 24

OCTOBER 27.

Corresponding altitudes of the sun, taken with the quadrant.

Time by the clock.

Eastern az. Western az. Meridian.

8h. 7' 18"	3h. 44' 30"	11h. 55' 54"
8 32	43 15	53. 5
9 14	42 32	53
10 48	40 56	52
12 6	39 40	53
15 41	36 15	58
17 23	34 26	54. 5
18 33	33 13	53
19 23	32 25	54
20 56	30 48	52
24 11	27 36	53. 5

M 2

Eastern

Eastern az.	Western az.	Meridian.
25' 25"	26' 18"	51' 5"
26 21	25 33	57
29 39	22 16	57, 5
31 12	20 36	54
33 21	18 28	54, 5
35 5	16 48	56, 5
36 27	15 26	56, 5

Mean,
Equation of altitudes,
o's center on the meridian,
Clock too slow,
Clock gains in 24 hours,

11^h 55' 54, 33
+ 16, 40
11 56 10, 73
3 49, 27
49, 20

OBSERVATIONS OF THE ECLIPSE.

Four persons observed the solar eclipse with me. Professor Sewall, James Winthrop, Esq; Messrs. Dudley Atkins, and John Davis, two young gentlemen of the University, who had made good proficiency in mathematical studies, and been pretty constantly employed in making observations for several days before.

At 8^h 20', A. M. with an object-glass micrometer applied to a reflecting telescope of twelve inches focus, made by *Short*, I measured the sun's diameter parallel to the horizon, and by a mean of ten observations, I found it 32' 17'', 33.

With a reflecting telescope of two feet focal length, made by *Short*, and a magnifying power of ninety times, I observed the beginning of the eclipse at 11^h 11' 8''.

Soon

Soon after I had noted the beginning, I adjusted the micrometer to the direction of the shadow ; and during the increase of the eclipse, made the following observations on the quantity.

App. time.			Lucid Parts by the Micrometer.		Lucid Parts reduced.	App. time.			Lucid Parts by the Micrometer.		Lucid Parts reduced.
h.	'	"	Rev.	Parts.		h.	'	"	Rev.	Parts.	
21	27	58	I	11	16	25	12	8			
	29	1		10	16	24	31	8			
	30	12		9	12	23	42	5			
	33	38		8	7	22	51	0			
	35	49		7	18	22	32	6			
	38	14		5	12	20	57	9			
	42	24		3	4	19	19	3			
	45	24		1	6	18	1	2			
	49	36	0	23	15	16	16	3			
	51	53		22	7	15	18	8			
	54	33		21	18	15	0	3			
	56	16		19	13	13	27	8			
	58	35		18	7	12	34	4			
						12	0	48			
						4	0				
						6	52				
						9	3				
						12	48				
						13	38				
						17	26				
						19	36				
						21	24				
						22	51				
						25	13				
						26	50				
						28	48				
									17	19	12 17, 9
									16	10 d	11 18, 3
									13	7	9 8, 8
									12	2	8 17, 4
									10	15	7 21, 9
									9	16	6 42, 8
									7	2	4 51, 9
									6	17 d	4 41, 5
									5	14 d	3 54, 3
									4	18	3 21, 4
									2	10	1 42, 7
									1	13	1 7, 8
									12		24, 7

Immediately after the last observation, the sun's limb became so small as to appear like a circular thread, or rather like a very fine horn. Both the ends lost their acuteness, and seemed to break off in the form of small drops or stars ; some of which were round, and others of an oblong figure. They would separate to a small distance : Some would appear to run together again, and others diminish until they wholly disappeared. Finding it very difficult to measure the lucid part any longer, I observed again in the larger telescope, looking out for the total immersion. After viewing the sun's limb about a minute, I found almost the whole of it thus broken or separated in drops, a small part only in the middle remaining connected. Plate I. Fig. VII. This appearance remained about a minute, when one of my assistants, who was looking at the sun with his naked eye, observed

served that the light was increasing. At this time I could not see any appearance of an increase of the lucid part. At 12^h 31' 18", it was evident that the broken parts of the sun's limb began to increase and unite. I immediately applied to the micrometer and measured the chord of the lucid part, and found it amounted to 42° or 43°: This was from the extremity of each limb taken from the most distant parts that were visible. I then measured the connected part of the limb, and found it to be 24° or 25°. As the light and limb were by this time very sensibly increasing, I again began to measure the quantity of the lucid part, and made the following observations with the micrometer.*

App. time.			Lucid Parts by the Mi- crometer.		Lucid Parts reduced.	App. time.			Lucid Parts by the Mi- crometer.		Lucid Parts reduced.
h.	'	"	Rev.	Div.		h.	'	"	Rev.	Div.	
12	33	36	0	1 11	1 3, 7	6	10		21	1	14 25, 3
	35	48		3 1	2 5, 3	12	29		1	0 0	17 7, 8
	38	13		4 8	3 0, 8	14	5		1	7	18 8, 3
	40	18		5 13	3 52, 2	17	53		3	5	19 21, 4
	45	24		8 15	5 59, 7	21	5		5	0	20 33, 3
	47	21		10 19	7 30, 1	24	46		7	7	22 9, 9
	49	7		11 2	7 36, 3	30	12		10	12	24 23, 5
	51	55		12 11	8 35, 9	33	12		12	8	25 37, 5
	54	13		14 17	10 10, 4	35	41		14	19	27 22, 3
	56	15		15 3	10 22, 7	39	6		16	19	28 44, 6
	58	0		16 5	11 8, 0	42	25		18	19	30 6, 8
1	2	59		19 5	13 11, 4	46	31		20	7	31 4, 4

The quantity of the lucid part being now become so large, I prepared to observe the end: And with the same telescope which I used at the beginning, I observed the end of the eclipse at 1^h 50' 25".

From

* I suspect there must be some inaccuracy in these observations. Some months after, upon examining the micrometer with which they were taken, I found some parts of it had been displaced.

From these observations it may be inferred, that the greatest obscuration was at $12^h 30' 12''$: At which time the sun's limb was reduced to so fine a thread, and so much broken as to be incapable of mensuration.

Professor Sewall observed with an achromatic telescope of 4 feet, made by *Dolland*, magnifying 40 times.

The beginning by his observation was at $11^h 11' 38''$. The end was not accurately ascertained, being disturbed in his observations by some of the spectators.

Mr. Winthrop observed with a reflecting telescope, made by *Nairne*, magnifying 55 times.

The beginning by his observation was at	$11^h 11' 38''$
Shadow touches the spots on the N. W. limb,	29 28
Spots totally immerfed,	30 0
Shadow touches the first spot in the western limb,	44 6
central spot,	46 8
eastern spot,	47 9
End of the eclipse,	1 50 17 to 21''

D. Atkins observed the beginning and end of the eclipse with a reflecting telescope of 12 inches focus, made by *Short*, magnifying about 55 times. His other observations were made with the telescope which I used to observe the beginning and end of the eclipse. The following is his account of his observations.

Beginning of the eclipse,	11 11 13
---------------------------	----------

The

The shadow touched the center of a large spot	11 30 12
on the western side of the sun's disc,	
The shadow touched the center of a long cluster of	
spots on the western side of the sun's center,	44 7
The shadow bisects the large spot in the sun's center,	46 24
The spot on the eastern limb of the sun half immersed,	12 27 1
The spot on the eastern limb of the sun half emerged,	40 18
The long cluster of spots on the western side of the	
sun half emerged,	40 28
The central spot half emerged,	1 7 1
The shadow left the center of the spot on the western side,	43 4
End of the eclipse,	1 50 28

J. Davis observed with the telescope on the quadrant. It gives a very distinct vision; but its magnifying power is but small. His account of his observations is as follows.

Beginning,	11 11 16
Shadow first touched the largest spot in the cluster	
on the N. W. limb,	29 10
wholly covered the same,	30 9
Shadow first touched a large spot near the center of	
the sun's disc,	46 14
wholly covered it,	46 53
First spot began to appear,	12 39 54
wholly free of the shadow,	41 13
Central spot first appeared,	1 6 25
free of the shadow,	7 14
Shadow leaves the sun,	1 49 58

To

To have a comparative view of the several observations, they are set down together in the following table.

Observers.	Beginning.	End.	Telescope made use of.	Magnifying power.
Mr. Williams,	11 ^b 11' 8"	1 ^b 50' 25"	2 feet reflector,	90
Mr. Sewall,	11 11 38		4 feet achromatic,	40
Mr. Winthrop,	11 11 38	1 50 17 to 21	1 foot reflector,	55
D. Atkins,	11 11 13	1 50 28	1 foot reflector,	55
J. Davis,	11 11 16	1 49 58	2½ feet achromatic,	small.

Whilst we were making the above observations, there was little wind, and no cloud to be seen. But the air was not perfectly clear, being a little thick, or hazy.

From the beginning of the eclipse unto the time of the greatest obscuration, the *colour* and *appearance* of the sky was gradually changing from an azure blue to a more dark or dusky colour, until it bore the appearance and gloom of night.

The degree of *darkness* was greater than was to be expected, considering the sun was not wholly obscured.—*Venus* appeared bright in the west; *Jupiter* was seen near the sun; *Lucida Lyræ* near the zenith, and *Aridef* in the north-east near the horizon, appeared very bright. Several others of the fixt stars were also seen whose situations were not particularly noted. Objects at a small distance appeared confused; and we were obliged to make use of candles to count our clock. But as soon as the greatest obscuration was past, it was universally remarked, that the increase of the light was much more rapid than that of the darkness had been.

As the darkness increased, a *chill* and *dampness* were very sensibly felt. To ascertain the quantity of *dew* that fell on a square
N. foot,

foot during the eclipse, we cut two pieces of very fine soft paper, exactly twelve inches square. Having weighed them in a nice balance, we placed them on an horizontal board in the open air. Just after the greatest obscuration we weighed one of them again, and found it's weight was increased by the *dew* that had fallen upon it, $4\frac{1}{2}$ grains *troy*. At the end of the eclipse we took up the other, and found it's weight increased by the *dew* that lay upon it, but 3 grains; $1\frac{1}{2}$ grain being evaporated as the light and heat of the sun increased. By a similar experiment, the quantity of *dew* that fell upon a square foot the night before, was found to be $6\frac{1}{2}$ grains; the night after the eclipse, 7 grains. Thus in 1 hour and 19 minutes, when the light and heat of the sun were rapidly decreasing, there fell two-thirds as much *dew* as fell the night before, or the night after the eclipse.

To determine what alteration might take place as to *heat* or *cold*, we made the following observations on Farenheit's thermometer, which was hung up in the open air, on the north side of a tree.

Time.	Therm.	Time.	Therm.
10 ^h . 0'	52°	12 ^h . 16'	53°
24	54 $\frac{1}{2}$	20	52
21 14	57 $\frac{1}{2}$	25	51
21	58	33	50
26	58	42	48
44	58	45	49
49	57	24	51
56	56 $\frac{1}{2}$	29	52 $\frac{1}{2}$
22 1	56	32	54
3	55	37	55
21	54	54	58

To

To this we may add, so unusual a darkness, dampness and chill, in the midst of day, seemed to spread a general amazement among all sorts of animals: Nor could we ourselves observe such unusual phenomena without some disagreeable feelings.

THE LATITUDE OF THE PLACE,

Computed from the observed zenith distance of the sun's upper limb.

OCTOBER 20.

Zenith distance of the sun's upper limb,	54° 44' 15"
Refraction,	+ 1 20
Sun's semi-diameter,	+ 16 8
Sun's parallax in altitude,	— 7
Zenith distance of the sun's center,	55 1 36
Sun's declination, south,	— 10 44 22
Latitude, north,	44 17 14

OCTOBER 24.

Zenith distance of the sun's upper limb,	56 8 17
Refraction,	+ 1 25
Sun's semi diameter,	+ 16 9
Sun's parallax in altitude,	— 7
Zenith distance of the sun's center,	56 25 44
Sun's declination, south,	— 12 8 43
Latitude, north,	44 17 1

OCTOBER 25.

Zenith distance of the sun's upper limb,	56 28 56
N 2	Refraction,

Refraction,	+	1' 26"
Sun's semi-diameter,	+	16 10
Sun's parallax in altitude,	—	7
Zenith distance of the sun's center,		56° 46 25
Sun's declination, south,	—	12 29 21
Latitude, north,		44 17 4
Mean of the above,		44 17 6,33

The LATITUDE computed from the observed zenith distance of several stars.

Rigel.

Mean of zenith distances, taken Oct. 24 and 25,		52 43 45
Refraction,	+	1 14, 7
True zenith distance,		52 44 59, 7
Declin. S. Jan. 1, 1770, by <i>Greenwich Observ.</i>		8 29 0, 2
Decrease in 10 years and 299 days,	—	52,78
Aberration,	—	8,29
Nutation,	—	5,20
Apparent declin. south, Oct. 25, 1780,	—	8 27 53,93
Latitude, north,		44 17 5,77

Sirius.

Mean of zenith distances, taken Oct. 24 and 25,		60 40 57
Refraction,	+	1 41, 2
True zenith distance,		60 42 38, 2
Declin. S. Jan. 1, 1770, by <i>Greenwich Observ.</i>		16 24 56, 1
Increase in 10 years and 299 days,	+	45,97
Aberration,	—	11,64
		Nutation,

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Nutation,	—	6", 90
Apparent declin. south, Oct. 25, 1780,	—	16° 25' 24, 13
Latitude, north,		44 17 14, 07

Procyon.

Mean of zenith distances, taken Oct. 24 and 25,	38 29 32
Refraction,	+ 45, 3
True zenith distance,	38 30 17, 3
Declin. N. Jan. 1, 1770, by <i>Greenwich Observ.</i>	5 47 55, 2
Decrease in 10 years and 299 days,	— 1 20, 58
Aberration,	+ 4, 71
Nutation,	+ 8, 10
Apparent declin. north, Oct. 25, 1780,	+ 5 46 47, 43
Latitude, north,	44 17 4, 73
Mean of the above,	44 17 8, 19
Latitude from observations of the sun,	44 17 6, 38
Latitude from observations of the stars,	44 17 8, 19
Mean of both,	44 17 7, 26

In computing the latitude I have made use of the table of refractions inserted in the Greenwich observations. But from several observations I have reason to think that the refractions in *Penobscot-Bay* are not uniform and regular; but that they vary very much with the winds and weather in that uncultivated part of the country.

As to our longitude, I could have wished to have had some observations of the eclipses of Jupiter's satellites, and of the occultations

cultations of the fixed stars by the moon. But no observations of this kind could be made. Comparing my observation of the beginning and end of the eclipse with observations made at *Cambridge, Chelsea, and Beverly*, and thence computing the difference of meridians, I find our observatory on *Long-Island*, was $9^{\circ} 20''$ to the east of *Cambridge*.

The longitude of the place of our observation agrees very well with what we had supposed in our calculations. But the latitude is near half a degree less than what the maps of that part of the country had led us to expect. On this account our situation, instead of falling within the limits of the total darkness, proved to be very near the southern extremity.

10. Observations of a lunar eclipse, November 11, 1780, at
Cambridge.

The clock was regulated by equal altitudes of the sun, taken by Mr. Gannett and Mr. Mellen. At $8^h 40'$, I measured the moon's diameter parallel to the horizon with an object-glass micrometer, and by a mean of seven observations, found it to be $30' 45'' 9$.

Beginning of the eclipse, by

Mr. Williams, with an achromatic telescope	Temp. app.
magnifying 90 times,	$10^h 21' 9''$
Mr. Gannett, with a reflector magnifying 55 times,	$10 \ 21 \ 23$
J. Dawson, with a reflector magnifying 60 times,	$10 \ 21 \ 37$

End of the eclipse, by

Mr. Williams,	$13 \ 22 \ 22$
Mr. Gannett,	$13 \ 22 \ 21$
Mr. Mellen, with a reflector magnifying 55 times,	$13 \ 22 \ 24$
	At

At the time of the greatest obscuration the quantity of the lucid part, as near as I could measure it with the micrometer, amounted to $5' 39''$, 2.—But this observation, and those made on the end of the eclipse, must be viewed as attended with some uncertainty. The shadow of the earth, throughout the whole eclipse, was very ill-defined: And from the middle to the end of the eclipse, the moon was partly obscured by very thin whitish clouds, which made it extremely difficult to distinguish the limits of the shadow, or the exact time when it left the moon's limb.

II. Observations of a lunar eclipse, March 28, 1782, at Cambridge.

Three gentlemen of the University observed this eclipse with me:—James Winthrop, Esq; Librarian, John Mellen, A. M. Mathematical Tutor, and Elijah Paine, A. B. The observations we made were as follow.—

Mr. Williams's observations.

	Temp. app.
Beginning of the eclipse,	$14^h 13' 16''$
Shadow reaches <i>Tycho</i> ,	28 58
<i>Grimaldus</i> ,	31 3
covers <i>Grimaldus</i> ,	37 51
reaches <i>Copernicus</i> ,	15 4 10
<i>Mare Tranquillitatis</i> ,	8 40
<i>Tycho</i> appears,	16 26 27
leaves <i>Tycho</i> ,	28 19
<i>Mare Crisum</i> ,	29 25
End of the eclipse,	53 41
End of the penumbra,	55 51
	These

These observations were made with an achromatic telescope magnifying 90 times, made by *Nairne*. At 13^h 30', I measured the moon's horizontal diameter with an object-glass micrometer applied to a reflecting telescope of 12 inches focus, made by *Short*, and by a mean of five observations I found it 33' 12". The greatest obscuration was at 15^h 34' 33", when the lucid part of the moon, measured by the micrometer, was 11' 31", amounting to 4 digits 11': Whence the quantity of the eclipse was 7 digits 49'.

Mr. *Winthrop's* observation.

	Temp. app.
Eclipse began,	14 ^h 13' 42"
Shade reached <i>Tycho</i> ,	28 5
<i>Tycho</i> wholly eclipsed,	30 24
<i>Grimaldus</i> ,	33 27
<i>Grimaldus</i> quite eclipsed,	37 42
<i>Insula Ventorum</i> eclipsed,	59 22
<i>Copernicus</i> ,	15 4 6
<i>Cusps</i> horizontal,	48 59
<i>Tycho</i> begins to emerge,	16 26 6
quite out of the shade,	27 49
End of the eclipse,	53 15
End of the penumbra,	53 45

Mr. *Winthrop* observed with a reflector, made by *Nairne*, fitted with vertical and horizontal wires, magnifying 55 times.

Mr.

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Mr. Mellen's observation.

	Temp. app.
Beginning of the eclipse,	14 ^h 14' 5"
Shadow first touched <i>Mare Humorum</i> ,	22 43
<i>Sinus Epidemiarum</i> ,	23 44
<i>Tycho</i> begins to immerge,	27 7
wholly immersed,	28 34
<i>Grimaldus</i> begins to immerge,	31 41
wholly immersed,	37 51
<i>Lausbergius</i> begins to immerge,	49 46
<i>Insula Ventorum</i> begins to immerge,	53 21
<i>Copernicus</i> begins to immerge,	15 3 5
wholly immersed,	14 1
<i>Mare Crisium</i> begins to immerge,	27 51
<i>Tycho</i> begins to emerge,	16 25 51
wholly emerged,	28 21
<i>Mare Crisium</i> wholly emerged,	29 51
End of the eclipse,	54 36
End of the penumbra,	55 31

These observations were made with an achromatic telescope, made by *Dolland*, magnifying 40 times.

Mr. Paine's observation.

Beginning of the eclipse,	14 14 26
Shadow reaches <i>Grimaldus</i> ,	32 16
covers <i>Grimaldus</i> ,	35 59
reaches <i>Copernicus</i> ,	15 2 54
<i>Grimaldus</i> begins to emerge,	38 23
is wholly emerged,	42 17
<i>O</i>	<i>Tycho</i>

<i>Tycho</i> begins to emerge,	16 ^h 26' 49"
is wholly emerged,	27 52
<i>Mare Crisium</i> wholly emerged,	29 18
End of the eclipse,	53 11
End of the penumbra,	56 11

Mr. *Paine's* observations were made with a reflector, made by *Short*, magnifying 55 times : But this was the first eclipse he had ever observed.

These observations were made at the house of Professor *Williams*. The times were shewn by an excellent astronomical clock, made by *Ellicott*, which was carefully regulated by corresponding altitudes of the sun. The weather was very favourable for observation.

In lunar eclipses the shadow is so imperfectly defined that the beginning and end can seldom be observed without an uncertainty of one minute, and sometimes of two or three minutes. In this eclipse, the circumstances were favourable for observation.

To have a comparative view of the several observations, those phenomena are set down in the following table, which were noted by each observer.

Phases observed by Mess'rs.	Williams,	Winthrop,	Mellen,	Paine.
Beginning of the eclipse,	14 ^h 13' 16"	14 ^h 13' 42"	14 ^h 14' 5"	14 ^h 14' 26"
Shadow reaches <i>Tycho</i> ,	28 58	28 5	27 7	
<i>Grimaldus</i> ,	31 3	33 27	31 41	32 16
covers <i>Grimaldus</i> ,	37 51	37 42	37 51	35 59
reaches <i>Copernicus</i> ,	15 4 10	15 4 6	15 3 5	15 2 54
<i>Tycho</i> begins to emerge,	16 26 27	16 26 5	16 25 51	16 26 49
wholly emerged,	28 19	27 49	28 21	27 52
<i>Mare Crisium</i> wholly emerged,	29 25		29 51	29 18
End of the eclipse,	53 41	53 15	54 36	53 11
End of the penumbra,	55 51	55 45	55 31	56 11

12. Observations

12. Observations of a solar eclipse, April 12, 1782, at Cambridge.

We had not any compleat observation of the beginning of this eclipse, being interrupted by small fleeting clouds passing over the sun. At $12^h 10' 45''$, I had a clear view of the sun, and could not see any appearance of the eclipse. At $12^h 11' 15''$, I discerned a darkness upon the western limb, but could not determine whether it was occasioned by a thin whitish cloud which was then passing over the sun, or whether it was the beginning of the eclipse. At $12^h 11' 45''$, the cloud left the western limb, and it was apparent that the eclipse began some time before. From these circumstances I think it probable that the beginning of the eclipse was very near $12^h 11' 15''$. Mr. Paine made the same remarks upon the beginning; but noted the darkness 5 or 6 seconds sooner than I perceived it.

At the end of the eclipse we had very good observations; the air being clear, and the sky free from clouds. These observations were as follow:

End of the eclipse

By Mr. Williams, with an achromatic telescope magnifying 90 times,	Temp. app. $2^h 51' 30''$
By Mr. Winthrop, with a reflector magnifying 55 times,	$2 51 28$
By Mr. Mellen, with an achromatic telescope magnifying 30 times,	$2 51 29$
By Mr. Paine, with a reflector magnifying 55 times,	$2 51 15$

At 12^h. I measured the sun's horizontal diameter with an object-glass micrometer, fitted to a reflecting telescope, and by a mean of five observations found it 31' 54". At 1^h. 34', the obscuration was the greatest: The lucid part of the sun was then 19' 9"; whence, the greatest eclipse was 4 digits 48'.

13. Observations of a lunar eclipse, September 10, 1783, at Cambridge.

The moon rose behind a cloud that lay along the horizon. At 7^h. 20', I saw her totally eclipsed. The eastern part was of that dusky copper-colour which is usual in total eclipses: But the western part was so obscure as to be almost invisible, except a circular appearance of light round her limb. At 7^h. 27", the clouds broke away, and I had a good observation of the

End of total darkness at 7^h. 41' 53"

In a few minutes the moon was again obscured by clouds: But at 8^h. 15", they dispersed and left a very clear sky; after which I made the following observations:

<i>Mare Serenitatis</i> wholly emerged,	8 22 38
<i>Mare Tranquillitatis</i> wholly emerged,	31 3
<i>Mare Crisium</i> begins to appear,	31 33
bisected,	33 38
wholly emerged,	35 43
End of the eclipse,	42 8

These observations were taken with an achromatic telescope magnifying 90 times: But the shadow did not appear to be very distinctly defined.

Mr. Mellen, with a reflecting telescope magnifying 55 times, made the following observations:

End

End of total darkness,	Temp. app.	7 ^h 41' 48"
Langrenus wholly emerged,		8 34 4
End of the eclipse,		42 3

Mr. Paine observed with an achromatic telescope magnifying 30 times. By his observation

The end of total darkness was at,	7 42 18
Bright spot in <i>Mare Vaporum</i> wholly emerged,	8 14 28
<i>Mare Tranquillitatis</i> wholly emerged,	31 88
End of the eclipse,	42 13

Both these gentlemen observed with me; and the times were taken by the same clock.

The last eleven eclipses were all that could be observed in this part of *America*, from Jan. 1, 1770, to Jan. 1, 1784.

Observations of the eclipses of *Jupiter's satellites*.

1782.

Temp. app.

June 25,	9 ^h 48' 30"	Em. 2d satellite.
July 2,	12 21 54	Em. 2d satellite.
3,	12 9 53	Em. 1st satellite.
Aug. 27,	9 6 25	Em. 1st satellite.
28,	9 3 49	Em. 2d satellite.
Sept. 12,	7 31 29	Em. 1st satellite.

These observations were taken with an achromatic telescope magnifying about 300 times. If they are compared with the calculations in the *Nautical Almanac*, the mean will give 4^h 44' 36" for the difference of meridians between the Royal Observatory at Greenwich, and the University at Cambridge in *America*.

Observations

Observations of the Transits of VENUS and MERCURY over the Sun, in the Years 1769, and 1782.

I. An observation of the transit of VENUS over the sun, June 3, 1769, at *Newbury*.

The transits of Venus over the sun are among the most uncommon and useful phenomena which astronomy ever presents to our view. I had the happiness of seeing that of 1761, at *St. John's*, in *Newfoundland*, attending the late excellent Dr. *Winthrop* in his voyage and observations at that place. That of 1769 I observed at *Newbury*, at the seat of *Tristram Dalton*, Esq; a gentleman of *Newbury-Port*.

The telescope I used was a reflector, made by *Nairne*, magnifying about 55 times; a good instrument, but not fitted with a micrometer, or with vertical and horizontal hairs, as I could have wished. The clock was a very good one, and carefully adjusted to apparent time by corresponding altitudes of the sun.

The weather for several days before the transit had been dull and rainy; but the third of *June* proved favourable to our wishes. The air was uncommonly clear, and the sky serene. About twenty minutes before the transit was expected, I began to keep my eye steadily fixed on that part of the sun's limb on which the planet, by calculation, was to enter; an assistant, counting the clock in the mean time, while another stood by to write down the observations. Thus prepared, we waited with a kind of agreeable anxiety for the high satisfaction of seeing Venus on the sun; a satisfaction I had once before enjoyed in viewing the transit of 1761, and which I knew must end with

with that of 1769. A small irregularity on the sun's limb seemed to denote the approach or first appearance of the planet. At $2^h 30' 14''$ apparent time, I suspected I saw a *small disturbance* on the sun's limb: But the impression was then so small, irregular, and ill-defined, that it was not till after several seconds that I was certain the transit was begun. The impression increasing and growing more distinct, I fixed on the time mentioned above as the time of the *external contact*. By observers, in the same state of the atmosphere, with telescopes and eyes equally good, and fixed on that part of the sun on which the planet entered, I imagine this first impression might have been observed to an agreement of five or six seconds.

Soon after Venus had first touched the sun's limb, the whole of her disc became visible: She appeared circular, and was surrounded with a pale glimmering light, not very distinctly defined. From this appearance I concluded it would be impossible to fix upon the precise moment when her limb would be exactly coincident with that of the sun, and therefore determined to wait till there should appear a small thread of light between them. As the *internal contact* drew near, the thread of light began to form, and seemed to dart on each side of the planet for several seconds without being fixed or settled. At $2^h 48' 44''$, with a seeming uncertainty of not more than seven seconds, it became closed and fixed. Venus then appeared wholly within the sun, separated from his limb by a fine stream of light flowing gently round it. This I fixed upon as the *internal contact*. Not having a *micrometer*, or hairs fixed in the reflector, instead of making any further observations, we could only enjoy the pleasure.

pleasure of viewing this curious phenomenon, and shewing it to a number of gentlemen who had assembled on the occasion.

In the above account of the *contacts* the duration of the ingress or passage of Venus over the sun's limb, is $18' 30''$; near one minute longer than in most of the *American observations*. By theory it should be $18' 56''$; but as this must have been contracted fifteen seconds by parallax at the place of observation, the apparent duration of the ingress would be but $18' 41''$; that is, eleven seconds longer than it was made by observation. I much doubt whether it was possible to discern the planet so soon as eleven seconds after the first contact, when not a second of its diameter had entered upon the sun. It seems more probable that the *internal contact* was past before the thread of light appeared to me to be completed.

The latitude of the place where this observation was made is $42^{\circ} 47'$, north. With regard to it's longitude, the mean of six observations of the eclipses of *Jupiter's satellites*, give it $1^{\circ} 26''$ in time east of *Cambridge*.

II. An observation of the transit of MERCURY over the sun, November 9, 1769, at *Salem*.

The transits of Mercury, though they are not of equal use in astronomy as those of Venus, are yet of great advantage to perfect the elements of his theory, and to determine the longitude of places on the earth. I had an opportunity to observe one of these transits at the house of *Andrew Oliver, Esq;* at *Salem*.

The

The only instrument we could procure was a reflecting telescope magnifying about 60 times. To ascertain the time I was obliged to make use of a *watch*, which for several days was carefully regulated by the sun's passage over the meridian. Taking the minutes from the watch, I counted seconds from one minute to another. And from the pains I took to be exact, I believe the time was well pointed out this way, though such as an Astronomer would by no means chuse.

At 2^h 54' 40" apparent time, Mercury came on the sun's limb as it were in an instant, in the form of a clear, regular, well-defined black spot. The *internal contact* was equally instantaneous. At 2^h 56' 0", the thread of light closed to appearance in a moment, without a seeming uncertainty of one second. The sky being perfectly clear and serene, nothing could be better defined than the limbs of Mercury and the sun: But the telescope did not admit of any further observations, either of the diameters of the sun and Mercury, or the least distance of their limbs.

The latitude of *Salem* is 42° 35' north; and it's longitude is about 1° 15' in time east of *Cambridge*.

III. Observations of the transit of MERCURY over the sun, Nov. 12, 1782, at the University in *Cambridge*.

Two gentlemen of the University observed this transit with me: *James Winthrop*, Esq; Librarian, and *Elijah Paine*, A. B.

The instruments which I used in observing this transit, were an achromatic telescope made by *Nairne*, with a magnifying power of 150; a reflecting telescope fitted with an object-

R

glass.

glass micrometer made by *Short*, with a magnifying power of 60; and an astronomical clock made by *Ellicott*. To regulate the clock with the greatest accuracy I took a large number of corresponding altitudes of the sun every day the weather would permit from the beginning of *October*, and found by the most careful attention that it kept equal time very exactly: The greatest error at any time not being more than two seconds in twenty-four hours.

On the 12th of November the weather was fair, but the air was not in the most favourable state for observation. Viewing the sun with an excellent achromatic telescope, I found the spots on the disc well defined; but the limb appeared to have an irregular, tremulous motion. This tremor, or undulation of the sun's limb, was of different degrees at different times; but it did not wholly cease any part of the day.

At 9^h 55', I began to keep my eye steadily fixed on that part of the sun's limb on which the planet was to enter; and at 10^h 6' 0'' apparent time, I saw the first appearance of *Mercury*. The impression seemed to be sudden and instantaneous, and without any uncertainty as to the time. But the appearance was not like the contact of two circles, or like that of a well-defined black spot entering upon the sun; but rather like a dark oval shadow instantly entering and mixing with the sun's limb. Plate I. Fig. VIII. While Mercury was thus entering upon the sun, no part of it was visible but that which was within the sun's disc. Its figure appeared to be elliptical: The greater axis seemed to pass through the point of contact, and to be about one-third longer than the other. This elliptical appearance of the planet made it impossible to determine when the
limbs

limbs of the sun and Mercury exactly coincided. I therefore estimated the *internal contact* by the first appearance of a small thread of light between them. This took place at 10^h 12' 17". The elliptical appearance was then wholly gone, and Mercury appeared circular, and perfectly well-defined. But the tremulous motion of the sun's limb was then so great, that this observation seemed to be attended with an uncertainty of eight or ten seconds.

When Mercury was wholly within the sun, I applied myself to the micrometer to measure the diameters of the sun and Mercury, and the least distance of their limbs. By a mean of eight observations taken during the transit, I found the sun's horizontal diameter to be 32' 21", 85: This was the same with the result of several similar observations made a little before the transit began, and just after it ended. To ascertain the diameter of Mercury, I made twelve observations at different times during the transit. The greatest care was taken to have them accurate: And the mean of all the measures gave it 9", 247.

In observing the least distance of the limbs of the sun and Mercury, I made the following observations:

Apparent time.	Least dist. of the limbs of ☉ & ☿.
10 ^h 34 ^m 53 ^s	12, 33
30 16	16, 44
41 22	18, 49
45 49	22, 00
47 0	22, 06
48 32	22, 06
54 42	18, 49
4 20	12, 00

I found considerable difficulty in measuring such small distances.—But the utmost attention was paid to these observations, as being some of the most useful and important of the whole: And I believe they were taken with as much exactness as the instrument would admit. Those near the middle I esteemed the most exact.

As Mercury approached the limb of the sun I again used the achromatic telescope; and at $11^h\ 23' 8''$, observed *the second internal contact*. Mercury was then perfectly circular and well-defined; and the undulation of the sun's limb less than before. This observation did not appear to me to be attended with an uncertainty of more than four or five seconds. While Mercury was passing the sun's limb, it's form again appeared elliptical, and the same phenomena took place which were noted at the former contacts, but in a much less degree. Just before the end of the transit, the limbs of Mercury and the sun appeared to be blended and mixed together. At $11^h\ 29' 19''$, Mercury seemed instantly to break off, separate, and disappear. This observation I esteemed the most exact of any I had made.*

To

* America was the most favourable place for observing this transit: And the undulation of the sun's limb seems to have been greater, in some parts of Europe, than it was here. On such accounts the American observations may be of much use in the records of astronomy. By a letter from M. DE LA LANDE, dated Paris, February 14, 1783, I find they have been viewed in this light by the ROYAL ACADEMY OF SCIENCES AT PARIS. “J’ai reçu, Monsieur, avec une extreme satisfaction vos lettres
“ avec les observations qui y étoient renfermées. Je les ai présentée a l’Academie
“ des Sciences, qui m’a chargé de vous en faire ses remerciemens, et qui les a définées a l’impression. J’ai donné moi-même au journal des savans votre observation
“ du passage de Mercure, qui m’a fait d’autant plus de plaisir que notre observation de Paris étoit fort douteuse a cause de l’ondulation des bords du soleil.”

To ascertain the diameter of the sun by other measures, about 1824 I made several observations of his passage over the meridian. These observations were taken with a transit telescope, fitted with three vertical hairs. The times were shewn by a curious watch, which distinguishes to a quarter of a second. The mean of ten observations gave $2' 16''$, 2, for the time of the sun's passing the meridian. This, reduced to parts of a circle, and multiplied by the co-sine of the sun's declination, gives $32' 24''$, 20, for the sun's apparent diameter.

Mr. Winthrop's observation.

The telescope Mr. Winthrop used was a large reflector, made by Short. Its aperture is eight inches, and its focal distance forty-eight. It has four magnifying powers—120, 260, 380, and 500. The magnifying power Mr. Winthrop used was 260. With this he observed

	Temp. app.
The first external contact at	10 ^h . 6' 31"
The first internal contact at	12 13
The second internal contact at	11 23 5
The second external contact at	29 10

With regard to these observations it should be noted, that the times in both our observations were taken by the same clock; but we observed at different parts of the house, and without any kind of communication together. The observations of the first external contact differ thirty-one seconds. Those of the first internal contact are within six seconds. Those of the second internal contact differ but three seconds: And in those of the last external contact there is no difference at all. The observation

I found considerable difficulty in measuring such small distances.—But the utmost attention was paid to these observations, as being some of the most useful and important of the whole: And I believe they were taken with as much exactness as the instrument would admit. Those near the middle I esteemed the most exact.

As Mercury approached the limb of the sun I again used the achromatic telescope; and at $11^h\ 23' 8''$, observed the *second internal contact*. Mercury was then perfectly circular and well-defined; and the undulation of the sun's limb less than before. This observation did not appear to me to be attended with an uncertainty of more than four or five seconds. While Mercury was passing the sun's limb, it's form again appeared elliptical, and the same phenomena took place which were noted at the former contacts, but in a much less degree. Just before the end of the transit, the limbs of Mercury and the sun appeared to be blended and mixed together. At $11^h\ 29' 19''$, Mercury seemed instantly to break off, separate, and disappear. This observation I esteemed the most exact of any I had made.*

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“ du passage de Mercure, qui m’a fait d’autant plus de plaisir que notre observation de Paris étoit fort douteuse a cause de l’ondulation des bords du soleil.”

To ascertain the diameter of the sun by other measures, about 12th I made several observations of his passage over the meridian. These observations were taken with a transit telescope, fitted with three vertical hairs. The times were shewn by a curious watch, which distinguishes to a quarter of a second. The mean of ten observations gave 2' 16", 2, for the time of the sun's passing the meridian. This, reduced to parts of a circle, and multiplied by the co-sine of the sun's declination, gives 32' 24", 20, for the sun's apparent diameter.

Mr. Winthrop's observation.

The telescope Mr. Winthrop used was a large reflector, made by Short. Its aperture is eight inches, and its focal distance forty-eight. It has four magnifying powers—120, 260, 380, and 500. The magnifying power Mr. Winthrop used was 260. With this he observed

	Temp. app.
The first external contact at	10 ^h 6' 31"
The first internal contact at	12 13
The second internal contact at	11 23 5
The second external contact at	29 10

With regard to these observations it should be noted, that the times in both our observations were taken by the same clock; but we observed at different parts of the house, and without any kind of communication together. The observations of the first external contact differ thirty-one seconds. Those of the first internal contact are within six seconds. Those of the second internal contact differ but three seconds: And in those of the last external contact there is no difference at all. The observation

ervation of the last external contact Mr. Winthrop supposes was attended with the greatest certainty: And he noted those optical phenomena which have been mentioned.

Mr. Paine's observation.

Mr. Paine used a reflector made by *Nairne*, magnifying 50 times. This telescope is fitted with vertical and horizontal hairs; and is so made that these hairs may be adjusted to any situation; to observe differences of altitude and azimuth, or those of right ascension and declination.

By his observation, the first external contact was at $10^h 7' 7''$. The internal contact was not accurately noted.

During the transit, he made the following observations of the difference of right ascension between the limbs of the sun and Mercury: The hairs in the focus of the reflector being so placed that the upper limb of the sun appeared to move along one hair, and of consequence, the other was perpendicular to the Equator.

	Temp. app.
1. Sun's preceding limb at the hair,	$10^h 25' 50''$
Mercury's center at the same,	27 35
Sun's succeeding limb at the same,	28 6
2. Sun's preceding limb at the hair,	32 49
Mercury's center at the same,	34 32 d
Sun's succeeding limb at the same,	35 6
3. Sun's preceding limb at the hair,	48 36
Mercury's center at the same,	50 13
Sun's succeeding limb at the same,	50 53
Sun's	

	4.	Temp. app.
Sun's preceding limb at the hair,	11 ^h 1' 58"	
Mercury's center at the same,	3 30	
Sun's succeeding limb at the same,	4 15	
5.		
Sun's preceding limb at the hair,	5 41	
Mercury's center at the same,	7 11	
Sun's succeeding limb at the same,	7 57	
6.		
Sun's preceding limb at the hair,	13 59	
Mercury's center at the same,	15 26	
Sun's succeeding limb at the same,	16 15	
Last internal contact,	22 5	
Last external contact,	28 6	

In respect to Mr. *Paine's* observations of the contacts we may remark, that they appear to have been carefully made, notwithstanding they differ so much from those made with much larger telescopes. The difference in the observations evidently arose from the difference of telescopes. Mercury was seen with an achromatic magnifying 150 times, 1' 7" sooner at the first contact, and 1' 13" later at the last contact, than it was with this small reflector. The mean of these, 1' 10", may be taken as the difference which arose from the difference of telescopes in observing so small an object as Mercury, in such a state of the atmosphere. Allowance being made for this difference, Mr. *Paine's* observations of the contact will be found to agree as well with the other observations of the contact, as they do with each other. The observations of the differences of right ascension would be very little affected by this cause, and therefore do not want any correction.

From

From these observations it will be easy to compute all the circumstances of this transit, and the principal elements of the theory of Mercury.

Thus, Plate I. Fig. IX. let the circle AEAQ represent the sun; NS the ecliptic; EQ a parallel to the equator; VA the apparent path of Mercury; NE part of Mercury's orbit. SA is a perpendicular to the equator; SE a perpendicular to the ecliptic; and SM a perpendicular to Mercury's visible way. The middle of the transit will be when Mercury arrives at the point M ; the ecliptical conjunction at E ; and the conjunction in right ascension at A . And N will represent the place of Mercury's ascending node.

The middle of the transit is given by the observations of the contacts. This,

By my observations of the external contacts, was at $10^{\text{h}} 47' 39''.5$ Temp. app.
By those of the internal contacts, $10^{\text{h}} 47' 37''.5$
My Mr. Winthrop's obs. of the internal contacts, $10^{\text{h}} 47' 39''$

The mean of which may be assumed as most exact, $10^{\text{h}} 47' 38''.66$

The visible conjunction of the sun and Mercury in right ascension, may be deduced from Mr. Paine's observations of their differences, &c. The result of these observations, as I have deduced them from calculation, are as follow:

Obs.	App. Time.	Difference R. A. of ☉'s cen- ter, and ☿ in Time.	Diff. R. A. in Parts of a Circle redu- ced to the Equator.	Time of Conjunction of ☉ and ☿ in Right Ascension.
1.	$10^{\text{h}} 27' 35''$	$37''$	$8' 48'' 2$	$12^{\text{h}} 5' 55''$
2.	$34' 32''$	34.5	$8' 12.3$	$12^{\text{h}} 5' 15''$
3.	$50' 13''$	28.5	$6' 46.8$	$12^{\text{h}} 5' 59''$
4.	$11^{\text{h}} 3' 30''$	23.5	$5' 35.4$	$12^{\text{h}} 5' 58''$
5.	$7' 11''$	22	$5' 14.0$	$12^{\text{h}} 5' 40''$
6.	$15' 26''$	19	$4' 31.3$	$12^{\text{h}} 5' 57''$

Mean, $12^{\text{h}} 5' 57''.33$

The

The apparent diameters of the sun and Mercury are also determined by observation.

By the micrometer measures, Mercury's diam. was 9", 247

The diam. of the sun by the microm. measures was 32' 21, 85

By the time of it's passing the meridian, 32 24, 20"

The mean of which may be taken as most exact, 32 22, 96

The least distance of centers is also had from observation.

By the micrometer measures this was 15 43, 70"

To examine the observations made by the micrometer, I computed by trigonometry what the least distance of centers would be by calculation from the observations of the contacts. The result gives the least distance

By my observations of the external contacts, 15 44, 1

By those of the internal contacts, 15 43, 5

By Mr. Winthrop's observ. of the internal contacts, 15 43, 6

The mean is the same as by the micrometer, 15 43, 73

From the observations of the diameters and least distance of centers, we may compute the length of the apparent transit-line, and Mercury's visible horary motion from the sun. In the right-angled triangle SMm , we have SM the least distance of centers, and Sm the sum of semi-diameters. Multiply the sum of Sm and SM by their difference, the square root of the product will be the length of Mm . By such a calculation (all the circumstances of the observations being taken into consideration) the length of the transit-line, estimated

By the external contacts, is 496", 2

By the internal contacts, is 423, 0

And hence,

By proportion, &'s vis. horary mot. from the sun was 5' 57, 33

From

From these *data* we may determine the angle of Mercury's visible way with the ecliptic, the geocentric latitude, and the time of the ecliptical conjunction. In the right-angled triangle SMA, SM is given, and MA is known by the visible horary motion of Mercury from the sun. Hence, we can find SA, and the angle MSA $26^{\circ} 13' 28''$. ESA is the angle made by that parallel to the Equator which passes through the sun's center at the ecliptical conjunction, and the ecliptic; and is equal to the sun's declination at that time, $17^{\circ} 52' 55''$. Subtract this angle from MSA, and we have the angle MSE, the angle of Mercury's visible way with the ecliptic, $8^{\circ} 20' 33''$. Again, in the right-angled triangle SME, we have SM, and the angle MSE; from which we can find SE and ME. The former is the geocentric latitude, and the latter is the difference between the middle of the transit and the ecliptical conjunction. By such a calculation corrected by parallax, at the ecliptical conjunction the geocentric latitude of Mercury was $15' 56'', 8$. And the time of ecliptical conjunction, Nov. $12^d 11^h 10' 58''$.

In the above calculation, the parallax of Mercury from the sun at the ecliptical conjunction, is supposed to be $3'', 09$ in latitude, and $1'', 50$ in longitude.

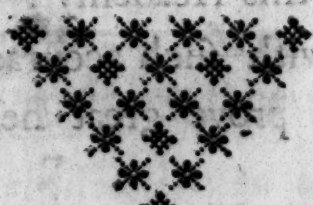
The geocentric latitude and the angle of Mercury's visible way with the ecliptic being known, we can also determine the place of Mercury's node, and the inclination of his orbit to the plane of the ecliptic. If we assume Mercury's distance from the earth to be 67683, and his distance from the sun 31198, his heliocentric latitude at the ecliptical conjunction will be $34' 36''$; his horary motion in the ecliptic, $15' 18'', 21$; and his horary motion in the ecliptic from the sun, $12' 47'', 01$.

Then

Then, in the the right-angled spherical triangle VSE, SE and the angle VES are known; from which we can find the side SV, $3^{\circ} 55' 33''$. If this be increased in the ratio of $12' 47''$, 01 to $15' 18''$, 21, we shall have the side SN, Mercury's distance from the node, $4^{\circ} 41' 59''$. Subtracting this from $7^{\circ} 20' 26' 36''$ the sun's place at the time of ecliptical conjunction, (by Mayer's tables) we shall have the place of Mercury's ascending node in γ , $15^{\circ} 44' 37''$.

Again, in the right-angled spherical triangle SNE, the sides SE and SN are given: From these we can find the angle SNE the inclination of Mercury's orbit to the plane of the ecliptic, $7^{\circ} 0' 13''$.

In computing the place of Mercury's node and the inclination of his orbit, the calculation chiefly depends on the angle of Mercury's visible way with the ecliptic. This may be computed from the observations of the *contacts*. But a very small error in those observations, will produce a very considerable one in the deductions. It was therefore thought best to deduce it from the observations of *right ascension*, which are equally convenient, and more numerous.



V. *Some select Astronomical Observations made at Chelsea, Latitude $42^{\circ} 25'$, and $26''$ in Time East of the University at Cambridge. By the Rev. PHILLIPS PAYSON, F. A. A.*

THE use of astronomical observations, to promote the purposes of navigation and geography, must be evident to every person that has paid any proper attention to the subject. By comparing observations made in different places, it is well known, special advantages accrue; and by transmitting those of one age down to another, affords astronomers, in future time, great helps for improvement: And no doubt but improvements will be made in this divine science to the end of time.

The extensive territories of the United States of *America*, are a foundation in nature for a vast empire.—The geography of its interior parts, though of great importance, is, at present, but little better than conjectural: To perfect which, and fix the interesting boundaries and lines, the best, and indeed the only proper method is, that of astronomical observations, which, it is probable, the Supreme Council of *America* will soon adopt, now the glorious revolution is so happily compleated. To promote such observations, both at noted head-lands upon the sea-coast, and at distant places in the interior country, highly merits the attention of this Academy: For though they should not at first be made with such accuracy as modern astronomy can boast of, they will prove great helps for future improvements.

The mode of observation, to determine the latitude of a place, is of very easy acquisition: Nor is that difficult which settles its longitude, if a person can be furnished with a good time-piece,

Hadley's

Hadley's quadrant, and a tolerable telescope. The eclipses of Jupiter's satellites being so frequent, and of such easy observation, they prove very favourable phenomena for this purpose.

But where great accuracy is required, a solar eclipse or an occultation of a star by the dark side of the moon, are to be preferred.

Several places in this and some other states in the union, have been determined in respect to each other, with much precision, from observations of late years. Such as shall be made in future, may correct some errors of the present.

The following observations were made with much care and attention. The clock was an excellent good one, regulated by equal altitudes of the sun taken by reflection with *Hadley's* quadrant: It was counted by a person much used to the thing; and in all of them, special care was taken in adjusting the equation of equal altitudes for the decrease or increase of the sun's declination.

The glass used, is a reflecting telescope, made by *Nairne*, better than 2 feet in length, and magnifying about 55 times. In a clear air, it shows the satellites of Jupiter to be nearly of the bigness of stars of the first magnitude.

Emerfions of Jupiter's satellites in the year 1779.

1st. Sattelite.

2d. Satellite.

	App. Time.
April 22,	10 ^h 37 ^m 3 ^s
May 8,	8 57 19
May 15,	10 52 7
June 23,	9 16 40

	App. Time.
May 29,	8 ^h 58 ^m 00 ^s
June 30,	8 39 15

3d. Satellite.

May 16,	8 54 20
23,	12 52 40
June 28,	8 36 11

Observations

Observation of a solar eclipse, June 24, 1778.

	App. Time.
Beginning, A. M.	9 ^h . 6' 42"
Middle,	10 21 55
End exact,	11 38 23

Observation of a lunar eclipse, May 29, 1779.

Immersion D's S. E. limb,	10 15 44
Ditto D's N. W. limb,	11 31 16
Emersion D's N. E. limb,	12 50 42
Ditto D's S. W. limb,	14 5 55

Observation of a solar eclipse, October 27, 1780.

Beginning,	11 00 58
Immersion of four spots, nearly in a line, just above the ☉'s center. Spot 1st. Plate II. Fig. I.	11 33 6
2d.	11 34 15
3d.	11 35 6
4th.	11 36 18

Immersion of a large spot nearly in the ☉'s center.

Beginning,	11 36 18
Spot covered, i. e. end,	11 37 20
Emersion of the four spots above the ☉'s center.	
Spot 1st.	12 53 3
2d.	12 54 23
3d.	12 55 5
4th.	12 56 9

Emersion of the large spot near the ☉'s center.

Beginning,	12 56 44
Completed,	12 57 45
Eclipse ended,	1 40 37
Duration,	2 39 39

At

At 11^h. 15^m, mercury in the thermometer stood at 59°.—
It sank gradually; and at 12^h. 30^m, stood at 51°.—Then gradu-
ally rose to 59°, at 1^h. 15^m. A little before 12^h, there appear-
ed a large halo, or circle, around the sun, and continued for
some time.

Observation of a lunar eclipse, November 11, 1780.

App. Time.

Beginning,	10 ^h . 27 ^m . 15 ^s .
End,	1 18 50
Duration,	2 51 35

Observation of a solar eclipse, April 12, 1782.

Beginning not observed, the face of the sun being
covered with clouds.

Correct app. time of the end of the eclipse, P. M. 2 52 21.

Observation of a transit of Mercury over the sun, November
12, 1782.

First ext. contact observed a few seconds too late,	10 7 41
First internal ditto,	10 12 36
Second internal ditto,	11 23 31
Second external ditto,	11 28 58
Duration of the transit,	1 21 17



VL. • *Observation of the Transit of Mercury over the Sun, November 12, 1782, at Ipswich. By the Reverend M^r MANASSEH CUTLER, F. A. A.*

CORRESPONDING altitudes of the sun were taken with a sextant, made by *Nairne and Blunt*, for regulating my clock, before and after the transit, viz.—On the 7th of Nov. were taken eight set of the upper, and nine set of the lower limb:—On the 8th, twelve set of the upper, and ten set of the lower limb:—On the day of the transit, eighteen set of the upper, and fourteen set of the lower limb, taken at different intervals:—On the 14th, nine set of the upper, and eleven set of the lower limb:—On the 15th, six set of the upper, and eight of the lower limb;—and on the 18th, seven set of the upper, and nine set of the lower limb. The equation of declination was added to each set of altitudes. By the result, found my clock went with great uniformity, but gained $7^{\circ}33''$ in twenty-four hours.

The day of the transit was clear and pleasant, with very little wind. My observation was made with a reflecting telescope, magnifying 45 times.

By an unfortunate accident, I failed of seeing the first external contact. At the time of the first internal contact, the sun's limb was exceedingly well-defined; but at the second internal and external contacts, the undulation of the limb was considerable.

First internal contact,
Second ditto ditto,
Second external ditto,

App. Time.
 $10^h 13' 37''$
11 24 15
11 30 20

VII. *A Memoir, containing Observations of a Solar Eclipse, October 27, 1780, made at Beverly: Also of a Lunar Eclipse, March 29, 1782,—of a Solar Eclipse, April 12, and of the Transit of Mercury over the Sun's Disc, November 12, the same Year, made at the President's House in Cambridge. By the Rev. JOSEPH WILLARD, President of the University.*

Observations of a solar eclipse, October 27, 1780, at Beverly.

I ATTENDED to my clock for a number of days before the eclipse, but more particularly on the 25th, 26th and 27th. On each of those days, the state of the atmosphere was favourable for taking corresponding altitudes of the sun. I took a number of double altitudes, both of his upper and lower limb, in the forenoon and afternoon, with *Hadley's* octant, by reflection from a bowl of very clear oil of tar, which was of such a consistence as to prevent undulation from the air, and in which, the solar image was extremely well defined. I noted the times by the clock, when the limbs of the two images of the sun just came into contact. The conjunction of the centers I did not attempt to take, because it cannot be determined with a certainty equal to the contact of the limbs.

The equation for the change of the sun's declination, during the half interval between the forenoon and afternoon observations, was constantly applied.

Observations of corresponding double altitudes of the sun, October 25.

	Foren. obs.	Aftern. obs.	Intervals.	$\frac{1}{2}$ Intervals.	Noon per clock nearly.
Sun's upper limb.	8 ^h 35' 2"	3 ^h 22' 46"	6 ^h 47' 44"	3 ^h 23' 52"	11 ^h 58' 54"
	8 39 40	3 18 8	6 38 28	3 19 14	11 58 54
	8 42 0	3 15 47	6 33 47	3 16 53 $\frac{1}{2}$	11 58 53 $\frac{1}{2}$
	8 44 23	3 13 25	6 29 2	3 14 31	11 58 54
		R			Sun's

	Foren. obs.	Aftern. obs.	Intervals.	$\frac{1}{2}$ Intervals.	Noon per clock nearly.
Sun's lower limb.	8h 50' 46"	3h 7' 5"	6h 16' 19"	3h 8' 9 $\frac{1}{2}$ "	11h 58' 55 $\frac{1}{2}$ "
	8 55 32	3 2 16	6 6 44	3 3 22	11 58 54
	9 0 24	2 57 30	5 57 6	2 58 33	11 58 57
	9 2 48	2 55 8	5 52 20	2 56 10	11 58 58

Time of noon nearly by the clock, by a mean of the above eight obs. 11 58 55
 Equation for change of declination in the $\frac{1}{2}$ interval, + 16

Exact time by the clock, when $\odot$'s center passed the meridian, 11 59 11
 Hence, the clock too slow for apparent time at noon, 49

In like manner observations were made on the 26th and 27th, the result of which it is sufficient to put down.

On the 26th,

When the sun's center passed the meridian, it was,
 by the clock, allowing for the equation, 11h 58' 16"
 Hence, the clock too slow for app. time at noon, 1 45

On the 27th,

When the sun's center passed the meridian, it was,
 by the clock, 11 57 18 $\frac{3}{4}$
 Hence, the clock too slow for apparent time at noon,
 on the day of the eclipse, 2 42 $\frac{3}{4}$

Loss of the clock, respecting apparent time, between
 the noon of the 25th and 26th, 56
 Ditto, 26th and 27th, 57

In the morning of the 27th, the Reverend Mr. Cutler, of Ipswich, and the Reverend Mr. Prince, of Salem, favoured me with their company, to observe the eclipse with me, Mr. Cutler and I were each furnished with a reflecting telescope, made by Mann, of London. The magnifying power of Mr. Cutler's, was 34, and that of mine, 45 times. Mr. Prince's telescope was an achromatic refractor of 3 feet. Its original magnifying power was 16 $\frac{1}{2}$; but he increased it to 43 times, by taking out the third glass of the sliding-tube, and adding another eye-glass of

of about an inch focus. We determined the magnifying power of our telescopes by *Hawksbee's* method.

We sat down to our telescopes about ten minutes before eleven o'clock, in a garden adjoining the room where the clock was fixed, and were so situated, that we could all very distinctly hear the person who counted the clock. Before we began to observe, we agreed that each one should note his times of observation, without speaking to the others, that all might determine for themselves, and no one might be in danger of being disconcerted.

We had a favourable time for observing the beginning and end of the eclipse. The immersions and emersions of a number of the solar spots were attended to by us; the situations of which, upon the disc, we determined as near as we could, a little while before we sat down to our telescopes. They then appeared to us as in Plate II. Fig. II. Mr. *Prince* had fixed parallel hairs in his refractor, dividing the sun's disc into four equal parts, horizontally. These hairs, together with a vertical one in the center, assisted us much in settling the places of the spots.

As we had no micrometer to measure the magnitude of the eclipse, we determined it by Dr. *Wallis's* method, published in *Whiston's* Astronomical Lectures, p. 188, 189. The eclipsed parts of the sun, marked at the time of the greatest obscuration, we afterwards measured upon a diagonal scale drawn for the purpose, by which we could determine to the fiftieth part of a digit.

At the middle of the eclipse, and for some time before and after it, there was a very great chilness in the air, and so much dew fell, that the papers we used abroad became quite damp.

The following are our observations of this eclipse, adjusted to apparent time.

	Mr. Willard.	Mr. Cutler.	Mr. Prince.
Beginning of the eclipse,	11h 1' 48"	11h 1' 42"	11h 1' 46"
Immersion of the western edges of solar spots.			
No. 1, of the western spots,	11 22 31	11 22 28	11 22 41
No. 1, of the north-eastern spots,	11 33 31	11 33 23	11 33 25
No. 3, of ditto,	11 35 21	11 35 22	11 35 23
A large spot near the center,	11 36 56	11 36 54	11 36 57
A fourth-eastern spot nearest the vert. diam.		12 11 34	12 11 37
Emergence of the eastern edges of solar spots.			
No. 2, of the western spots,		12 31 55	12 31 56
No. 1, of the north-eastern spots,	12 53 50	12 53 47	12 54 4
No. 2, of ditto,	12 54 53	12 54 57	12 55 0
No. 3, of ditto,	12 55 36	12 55 36	12 55 41
No. 4, of ditto,	12 56 32	12 56 31	12 56 38
The large spot near the center,	12 58 6	12 58 4	12 58 14
The end of the eclipse,	1 41 26	1 41 23	1 41 29
The duration,	2 39 38	2 39 41	2 39 43

By our observation, the greatest obscuration was at about 12^h 21', apparent time, when the parts eclipsed were 11 dig. 24'

The clock's rate of going was the same for several days following the 27th, as it had been for the two days preceding.

N. B. 1. By twenty-seven double altitudes of the sun, when upon the meridian, taken with a *Hadley's* octant, very accurately constructed, I have found the latitude of the house, where the foregoing observations were made, 42° 36' N.—The house stands facing the middle of the training-field, (so called) in the first parish in *Beverly*.

N. B. 2. By calculations from the observations of the foregoing eclipse made at *Beverly*, and those made at *Chelsea*, I find the difference of meridians to be 45" in time; which, added to 26", the difference between *Chelsea* and *Cambridge*, makes 1' 11" for the difference between *Cambridge* and *Beverly*. The difference between *Beverly* and *Penobscot*, where Professor *Williams* and company made their observations, I find, in the same way,

way, to be $8' 4''$, which makes the difference between *Cambridge* and *Penobscot* $9' 15''$. The difference between *Beverly* and *Providence*, by deductions from the observations, is $2' 18''$, which gives $1' 7''$ between *Cambridge* and *Providence*.

Observations of a lunar eclipse, March 29, 1782, made at the President's house in *Cambridge*.

The going of my clock was ascertained, for the observing of this eclipse, in the same manner as for the foregoing one of October 27, 1780.

Mr. *Caleb Gannett* observed the eclipse with me. The telescope I made use of was an achromatic refractor, with a magnifying power of 90. Mr. *Gannett* made use of a reflecting telescope, of about the same magnifying power. We had, upon the whole, a pretty favourable time; though the earth's shadow, at the moon, did not appear so well defined as we could have wished.*

The observations follow.

	Apparent Time.	
	By Pref. Willard.	By Mr. Gannett.
Beginning of the eclipse,	$2^h 14' 7''$	$2^h 14' 0''$ A. M.
Shadow touches <i>Harpalus</i> ,	22 51	22 57
<i>Tycho</i> ,	27 21	27 10
covers <i>Tycho</i> ,	29 16	29 4
touches <i>Mare Crisum</i> ,	3 28 49	3 28 10
leaves <i>Mare Crisum</i> ,	4 28 36	4 28 17
leaves <i>Mare Tranquilitatis</i> ,	33 40	34 7
End of the eclipse,	4 53 50	4 53 33

Observations:

* In observations of different lunar eclipses, when the state of the atmosphere, as far as the eye could determine, has been the same, the earth's shadow has appeared much better defined in one, than in another.

Observations of a solar eclipse, April 12, 1782, made at the President's house.

The going of my clock was ascertained in the same manner as at the time of the lunar eclipse, in March.

Mr. *Caleb Gannett* and Mr. *William King* observed the eclipse with me. Mr. *Gannett* and I had the same telescopes that we used for observing the lunar eclipse. Mr. *King* was furnished with a good reflecting telescope, the magnifying power of which was about 40. At the beginning of the eclipse the clouds were troublesome; so that the entrance of the moon upon the sun's limb was not seen by us, or by any of the observers in *Cambridge*. But the clouds dispersed soon afterwards, and the atmosphere became perfectly clear; so that we had a very favourable time for observing the end of the eclipse, which was,

	Apparent Time.
By President <i>Willard</i> , at	2 ^h 51' 41" P. M.
Mr. <i>Gannett</i> ,	2 51 27
Mr. <i>King</i> ,	2 51 41

As we were not furnished with a micrometer, no other observations, of any consequence, were made by us upon this eclipse. Observations of the transit of Mercury over the sun's disc, November 12, 1782, made at the President's house.

The going of my clock was determined, for this phenomenon, as for the eclipses, in the spring.

Mr. *Caleb Gannett* observed with me. We were furnished with the same telescopes that we made use of for observing the eclipses. Our observations were as follow.

	1st ext. cont.	1st int. cont.	2d int. cont.	2d ext. cont.
By Pres. <i>Willard</i> ,	10 ^h 6' 27"	10 ^h 12' 37"	11 ^h 23' 2"	11 ^h 29' 32" A. M.
By Mr. <i>Gannett</i> ,		10 12 45	11 23 36	11 29 29
Mean,		10 12 41	11 23 19	11 29 30½

Duration of the transit, $10^h 12' 41''$ — $10^h 6' 27''$
 internal 1 10 38 ext. 1 23 $3\frac{1}{2}$

The state of the atmosphere was unfavourable, during the transit. The limb of the sun appeared serrated; so that it was difficult to determine the contacts, with that precision which could be wished.

At the time of the first internal contact, and for some minutes after, the limb of γ , next to the sun's eastern limb, had an oval appearance; and his limb, next to the western limb of the sun, put on the same appearance, a few minutes before, and at the time of the second internal contact.

For γ 's horizontal parallax.

γ 's distance from the earth 67681 : the sun's distance from the earth 98879 :: the sun's horizontal parallax $8''$, 55 : γ 's horizontal parallax $12''$, 49. Therefore, γ 's horizontal parallax from the sun is $3''$, 94.

Elements for calculating γ 's parallax from the sun in latitude and longitude, at Cambridge, at the first external contact, November 12, 1782, at $10^h 6' 27''$, A. M. apparent time.

The sun's longitude,*	$7^s 20^{\circ} 23' 53''$, 304
Mercury's geocentric longitude,	7 20 30 12, 078
Mercury's geocentric latitude, north,	14 55, 754
The sun's right ascension,	227 57 5
The right ascension of the mid-heaven,	199 33 50
Angle answering to pPZ in Plate I. Fig. I.	70 26 10
The sun's horary motion,	2 31, 2
Mercury's geo. hor. mot. in long. in the ecliptic retro.	3 22, 32
	Mercury's

* The elements of the sun are calculated from Mayer's, and those of Mercury from M. de la Lande's tables.

Mercury's geo. hor. mot. from the sun in the ecliptic, $5^{\circ} 53' 52''$

Mercury's geo. hor. motion in latitude increasing, $51, 96$

The sun's semi-diameter, $16 12, 2$

Mercury's semi-diameter, $5, 11$

Mercury's horizontal parallax from the sun, $3, 94$

The obliquity of the ecliptic, $23^{\circ} 28' 12''$

The lat. of Cambridge reduced to the center, $42 8 37$

Hence,

The altitude of the nonagesimal degree, $44 24 32$

The longitude of the nonagesimal degree, $5^{\circ} 26' 45'' 44$

Mercury's parallax in latitude from the sun, $2, 807$

Mercury's parallax in longitude from the sun, $2, 224$

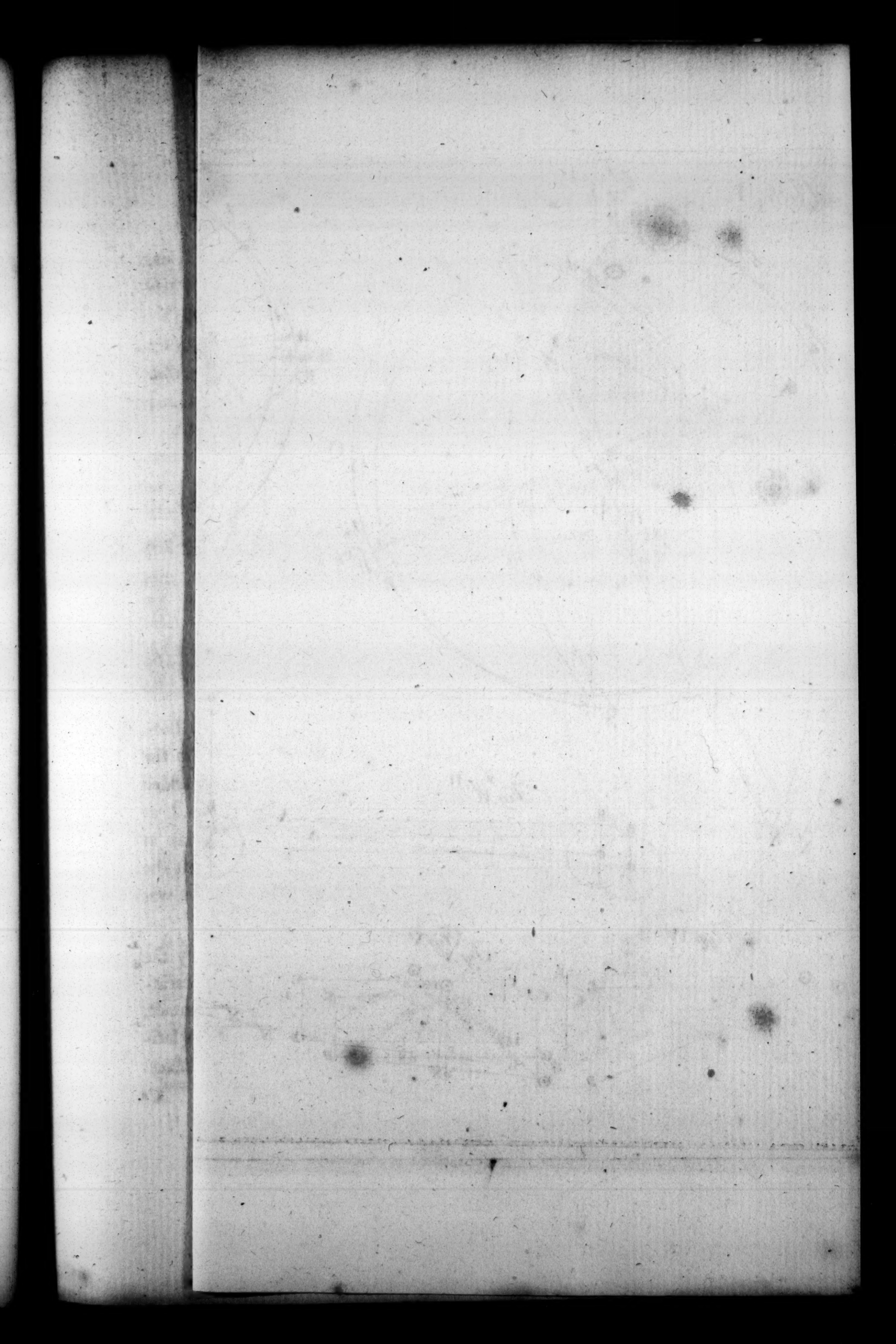
At the second external contact, at $11^h 29' 30\frac{1}{2}''$, A. M.
apparent time ; by calculation,

Mercury's parallax in latitude from the sun, $3, 169$

Mercury's parallax in longitude from the sun, $1, 280$

The longitude of the nonagesimal degree, at the time both of the first and second external contact, being less than the longitude of Mercury, the parallax in longitude is to be added to Mercury's longitude, in each, to give the visible ; and as Mercury's motion in transits is retrograde, and the parallax at the time of the second external contact was greater than at the time of the first, the length of the visible transit-line was greater than the true, by the difference of the parallaxes.

The true latitude, at each contact, was diminished by the parallax in latitude ; and as the geocentric latitude was increasing, and the parallax, at the time of the second external contact, greater than at the time of the first, the visible motion in latitude was less than the true, by the difference of the parallaxes.



h

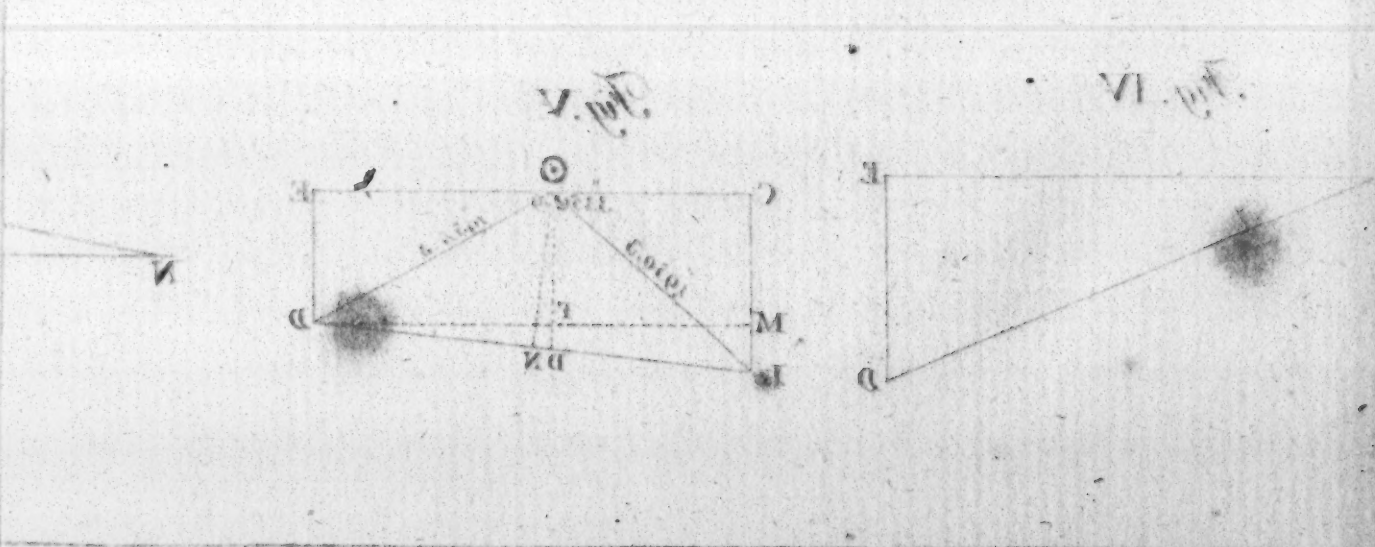
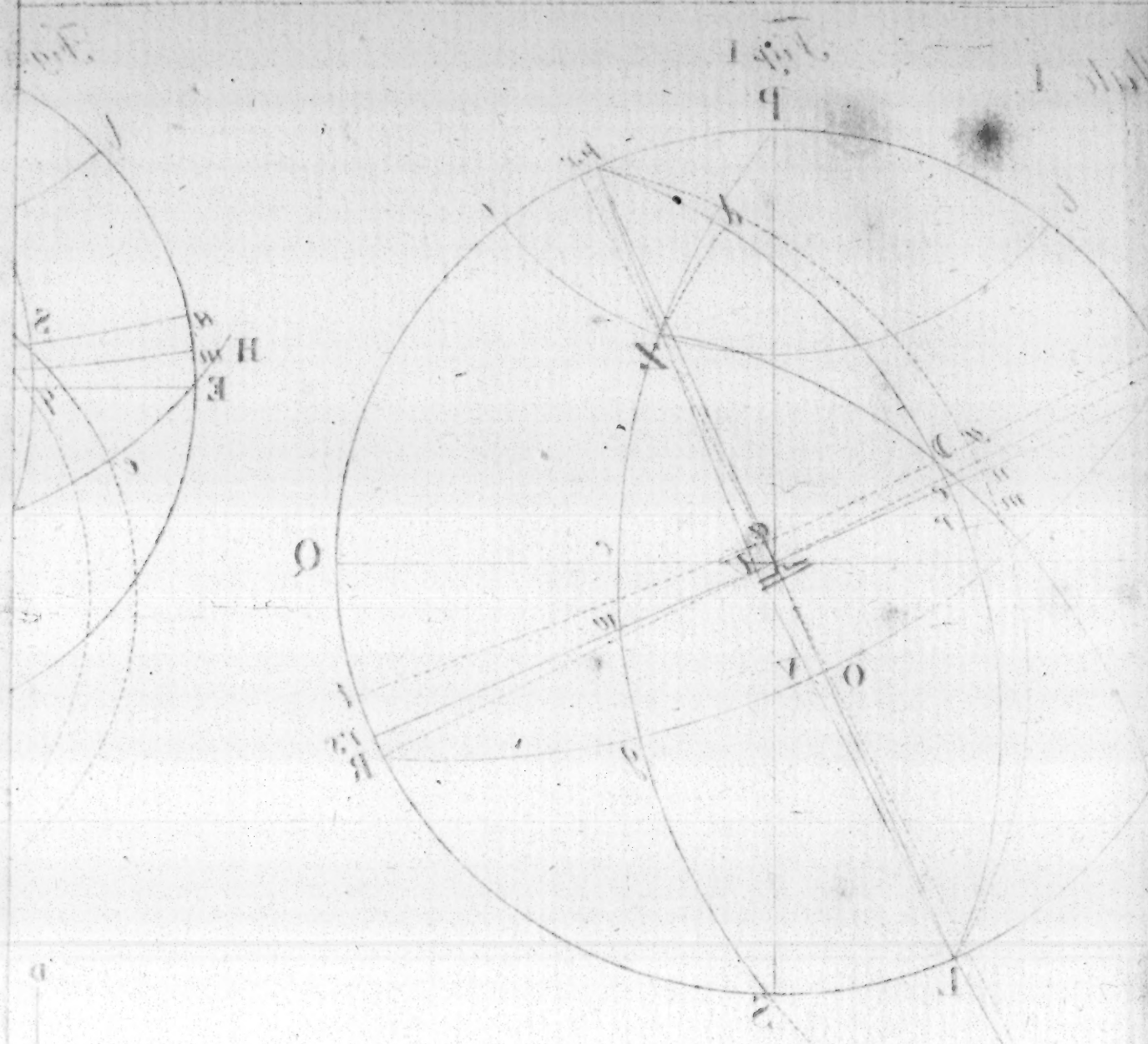
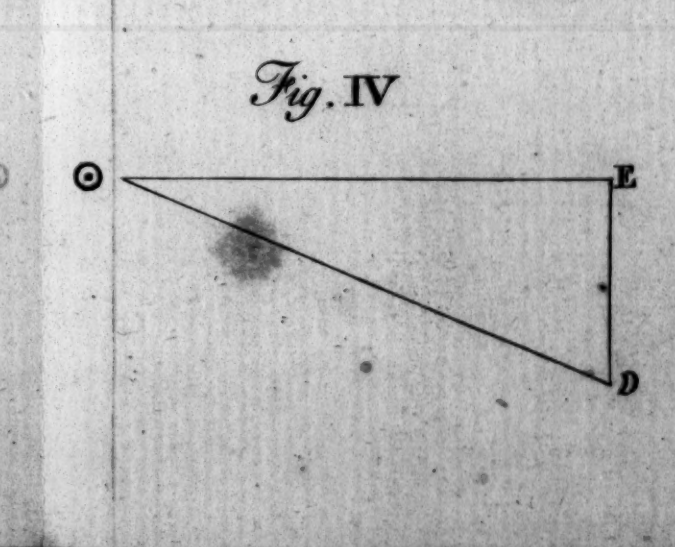
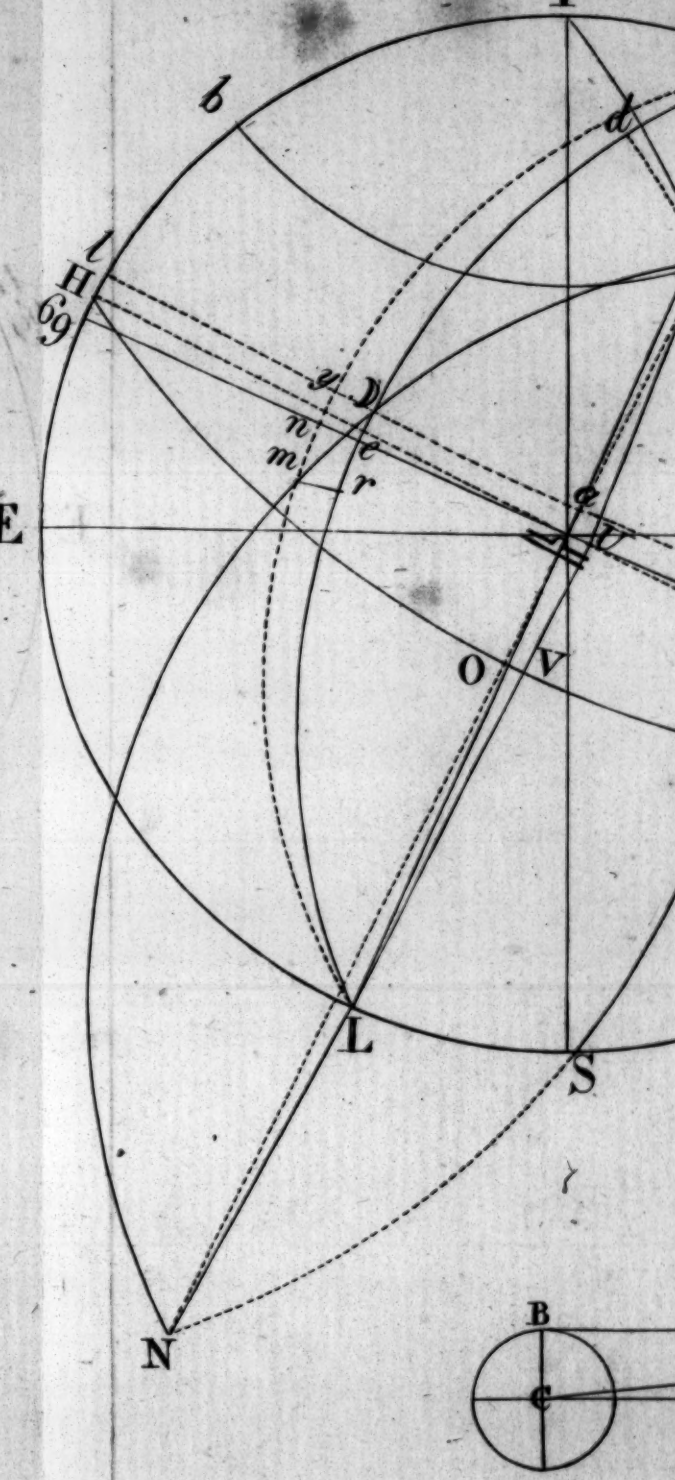


Plate I.



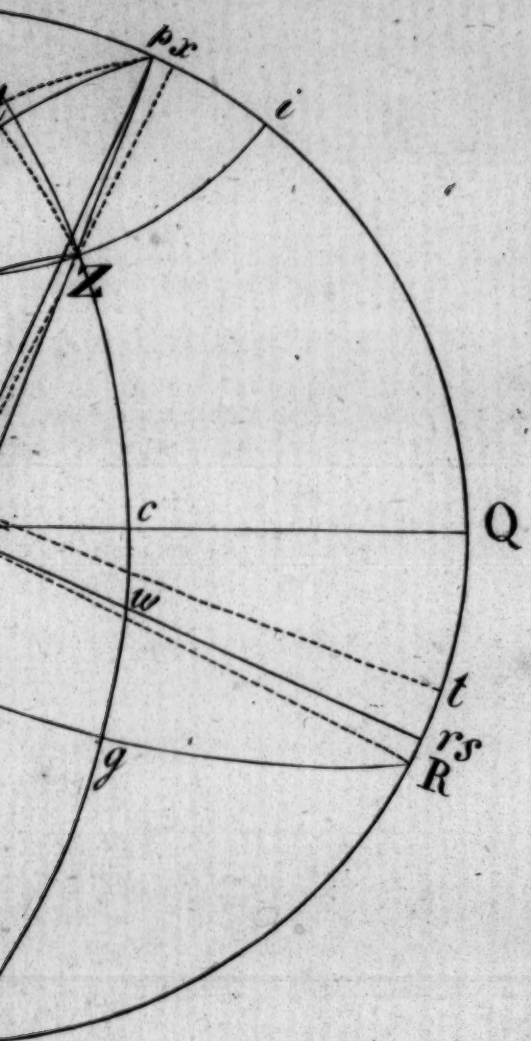


Fig. II

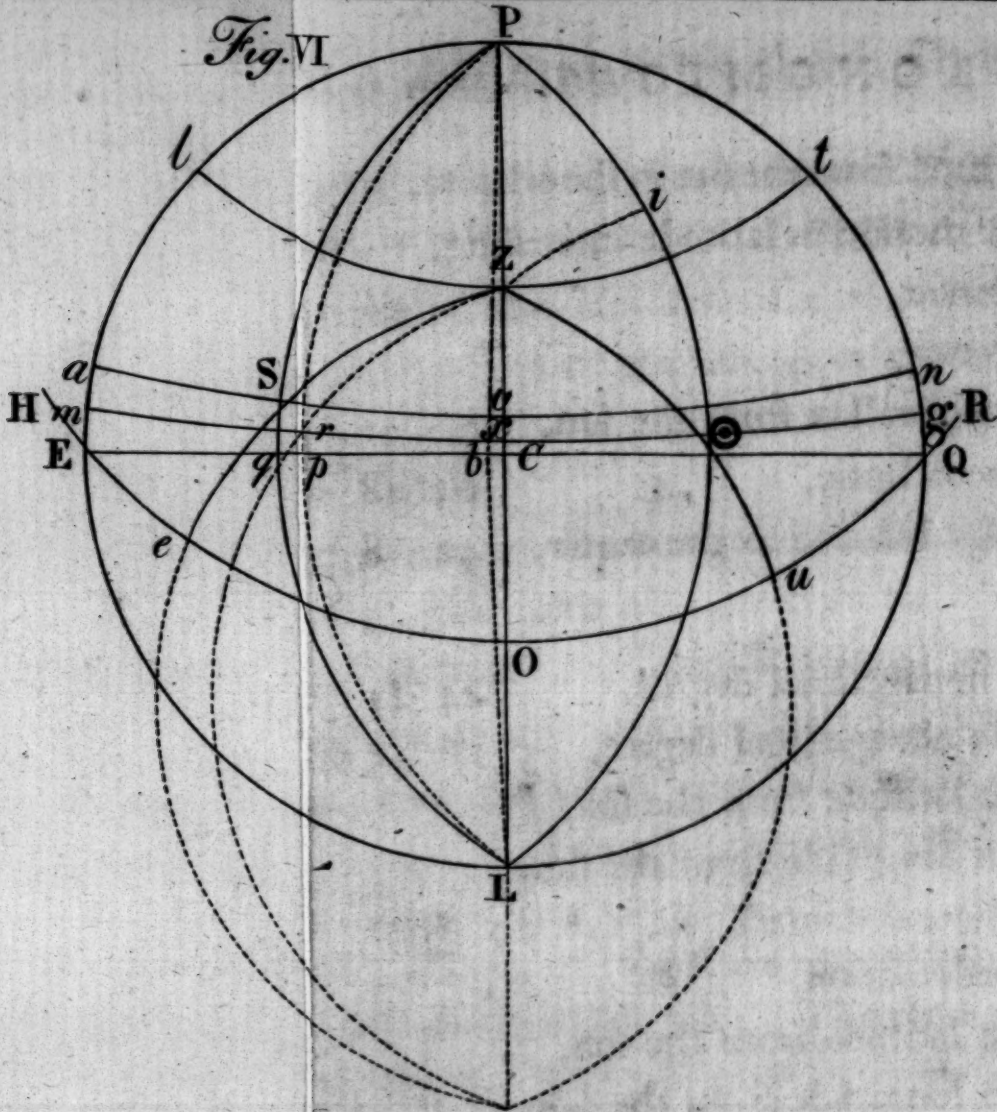


Fig. VI

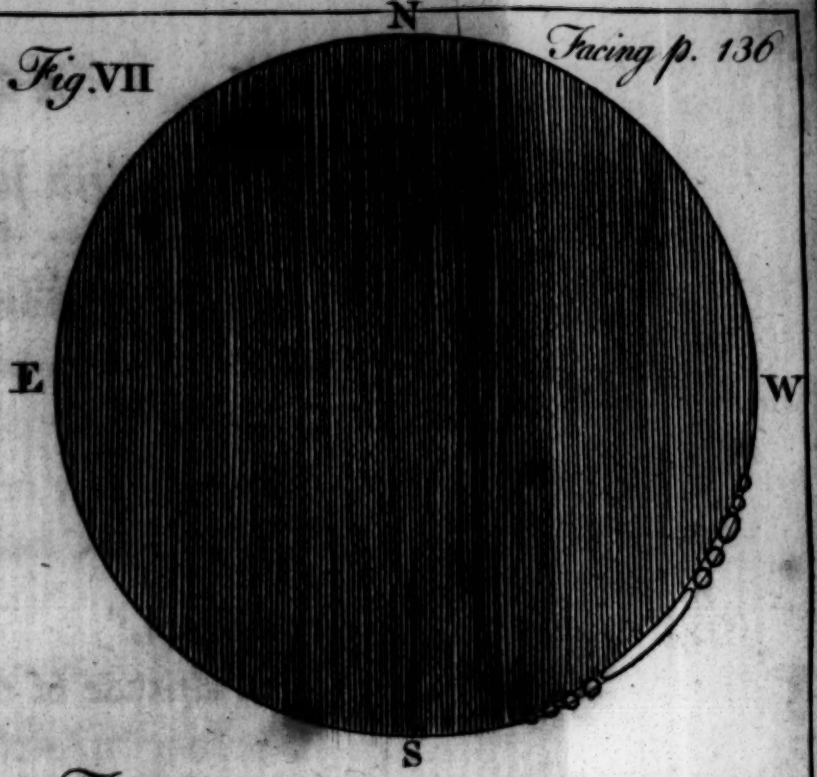


Fig. VII

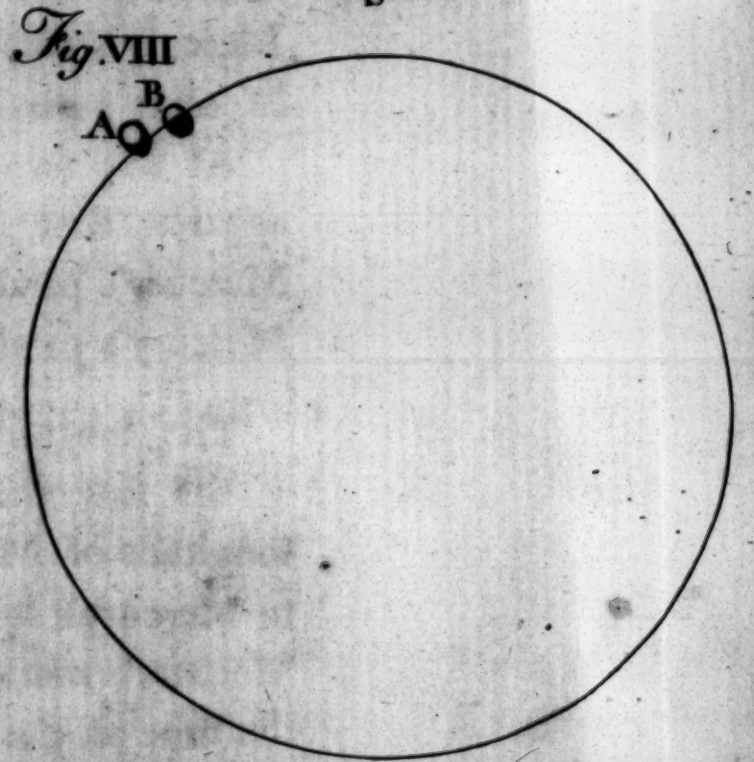


Fig. VIII

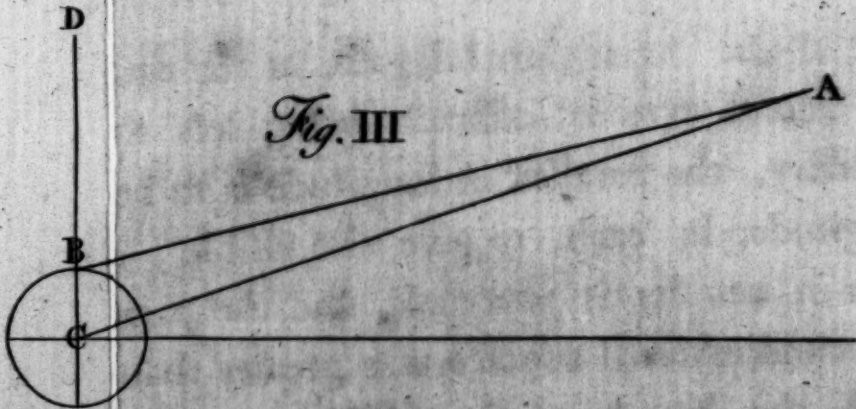


Fig. III

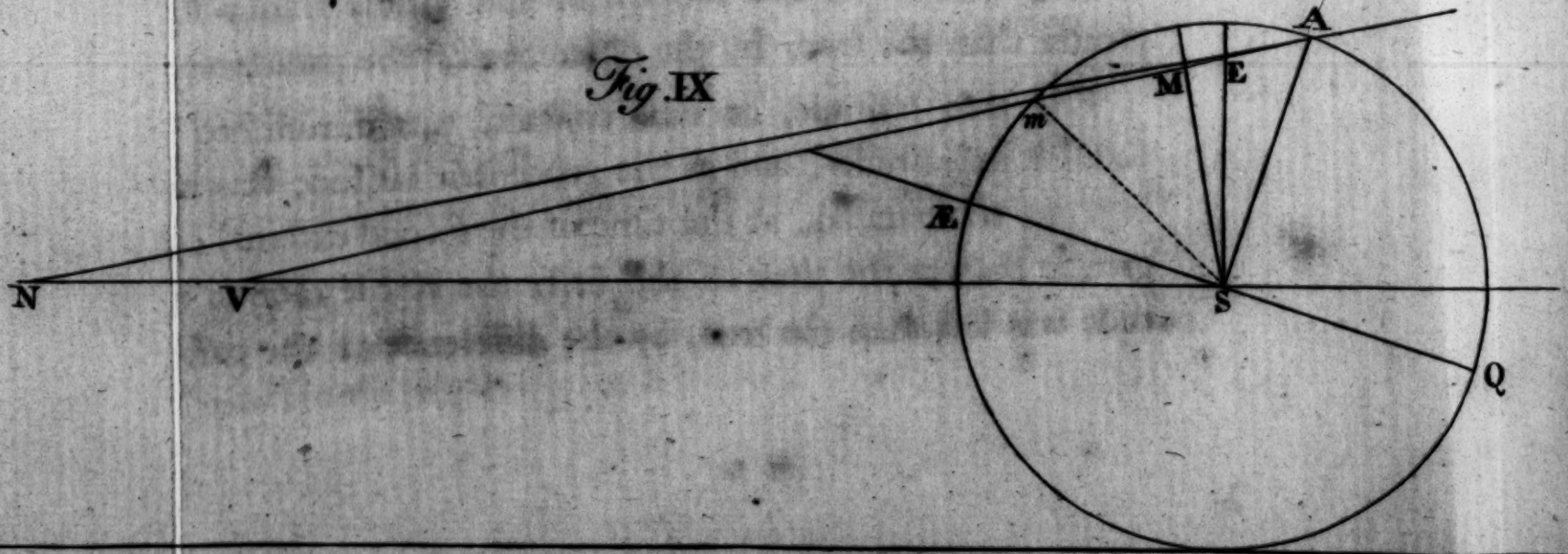


Fig. IX

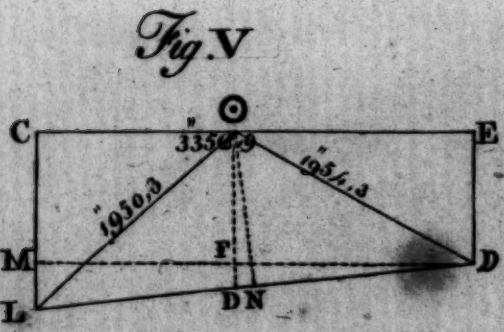
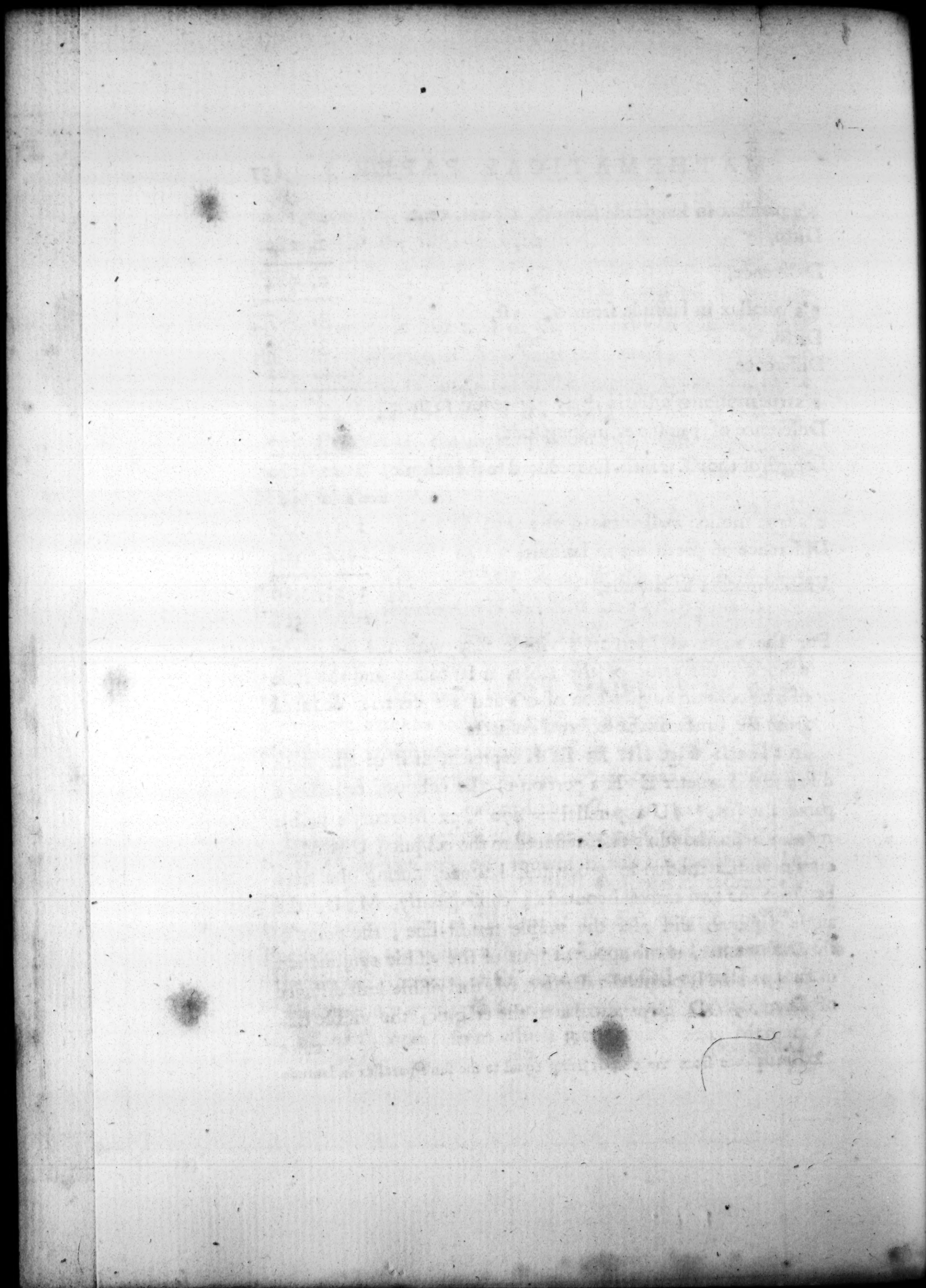


Fig. V



☿'s parallax in longitude from ☉, 1st ext. cont.	2", 224
Ditto, 2d,	1, 280
Difference,	<u>0, 944</u>
☿'s parallax in latitude from ☉, 1st,	2, 807
Ditto, 2d,	3, 169
Difference,	<u>0, 362</u>
☿'s true mot. on ☉'s disc in 1 ^h . 23' 3 $\frac{1}{2}$ " reduc. to the ecl.	8' 9, 376
Difference of parallaxes in longitude,	<u>+ 0, 944</u>
Length of the vis. transit-line reduced to the ecliptic,	8 10, 320
	= 490", 32
☿'s true motion in latitude in 1 ^h . 23' 3 $\frac{1}{2}$ ",	1 11, 928
Difference of parallaxes in latitude,	<u>- 0, 362</u>
Visible motion in latitude,	1 11, 566
	= 71", 566

For the angle of Mercury's visible way with the sun in the ecliptic; the error of the tables in latitude; and the time of the ecliptic conjunction of ☉'s and ☿'s centers, deduced from the times of the external contacts.

In Plate II. Fig. III. let EDK represent half of the sun's disc; the diameter E☉K a portion of the ecliptic, or rather a parallel to it; * ☿U a parallel = 490", 32 Mercury's visible motion upon the sun's disc, reduced to the ecliptic; UM Mercury's visible motion in geocentric latitude, during the time between the two external contacts; consequently, M☿U, the angle required, and ☿M the visible transit-line; the point ☉ the sun's center, at the apparent time of the visible conjunction of centers; ☉N, perpendicular to ☿M, the visible least distance of centers; ☉D perpendicular to the ecliptic, the visible distance

* The distance from the ecliptic being equal to the sun's parallax in latitude.

tance of centers, at the time of the visible ecliptic conjunction;
 $\odot$ and M the distance of centers, at the time of the external contacts, = the sum of the semi-diameter of the sun and of Mercury = $977''$, 3; $C\gamma$ the visible difference of latitude of the centers, at the time of the first external contact; LM the visible difference, at the time of the second; $C\odot = \gamma F$ the visible difference of longitude of the centers, at the time of the first; and $\odot L$ at the time of the second external contact.

For $M\gamma U$, the angle of Mercury's visible way.

γU $490''$, 32 : UM $71''$, 566 :: Radius : Tangent angle $M\gamma U$ $8^\circ 18' 15''$.

For γM , the visible transit line.

Sine $M\gamma U$ $8^\circ 18' 15''$: UM $71''$, 566 :: Radius : γM $495''$, 512. As $\odot$ and M are equal, the perpendicular $\odot N$ bisects γM ; therefore, γN and NM are $247''$, 756 each.

For angle $\gamma \odot N$,

$\odot\gamma$ $977''$, 3 : Radius :: γN $247''$, 756 : Sine angle $\gamma \odot N$ $14^\circ 41' 7''$. Add angle $N\odot D = M\gamma U$ $8^\circ 18' 15''$, the sum is = angle $\gamma \odot D = \gamma \odot F = \odot\gamma C = 22^\circ 59' 22''$; the complement of which is = angle $\gamma \odot C = 67^\circ 0' 38''$.

For side $C\gamma$ = Mercury's visible latitude from sun, at the first external contact.

Radius : $\odot\gamma$ $977''$, 3 :: Sine angle $\gamma \odot C$ $67^\circ 0' 38''$: $C\gamma$ $899''$, 68 = $14' 59''$, 68; to which add the parallax in latitude $2''$, 807, and the sum $15' 2''$, 487 is Mercury's true latitude by observation, at the time of the first external contact.

For side $C\odot$, the visible difference of longitude of the centers of the sun and Mercury, at the time of the first external contact.

Radius : $\odot\gamma$ 977 , 3 :: Sine angle $\odot\gamma C$ $22^\circ 59' 22''$: $C\odot$ = γF $381''$, 696; from which subtract $2''$, 224, Mercury's parallax

parallax in longitude from the sun, because his visible longitude was greater than the true, and the remainder, $379''$, 472 , will be the true difference of longitude.

For the apparent time of the true ecliptic conjunction, and Mercury's true latitude by observation,

Mercury's ecliptic horary motion upon $\odot$'s disc $353''$, $52 : 1^h = 3600'' ::$ the true difference of longitude $379''$, $472 : 3864\frac{1}{4}''$, the space of time from the first external contact to the ecliptic conjunction, $= 1^h$ $4'$ $24\frac{1}{4}''$; which, added to 10^h $6'$ $27''$, gives 11^h $10'$ $51\frac{1}{4}''$, for the apparent time of the true ecliptic conjunction.

In 1^h $4'$ $24\frac{1}{4}''$, Mercury's geocentric latitude was encreased $55''$, 774 ; which, added to $15'$ $2''$, 487 , his latitude at the first external contact, makes $15'$ $58''$, 261 , for Mercury's true latitude by observation, at the time of the true ecliptic conjunction, by the external contacts.

Deductions from the internal contacts.

Let the references be to Plate II. Fig. III. the lines $\odot g$ and $\odot M$ being supposed $=$ the difference of the semi-diameters of the sun and Mercury $= 967''$, 1 ; and, consequently, the transit-line wholly within the sun's disc.

$\odot$'s parallax in longitude from $\odot$, 1st int. cont.	$2''$, 158
Ditto, 2d,	1 , 355
Difference,	0 , 803
$\odot$'s parallax in latitude from $\odot$, 1st,	2 , 837
Ditto, 2d,	3 , 145
Difference,	0 , 308

☿'s true mot. on ☉'s disc in 1 ^h . 10' 38" reduc. to the ecliptic,	6' 56", 171
Difference of parallaxes in longitude,	+ 0, 803
Length of the vis. transit-line reduced to the ecliptic,	6 56, 974
	= 416, 974
☿'s true motion in latitude in 1 ^h . 10' 38",	1 1, 168
Difference of parallaxes in latitude,	— 308
Visible motion in latitude,	1 0, 86
	= 60, 86

Hence,

M☿U, the angle of Mercury's visible way $8^{\circ} 18' 15''$; —
 ☿M, the visible transit-line, 421'', 392; —angle ☿ON $12^{\circ} 35' 1''$, consequently, ☿OD = ☿OF = ☉☿C $20^{\circ} 53' 16''$, and
 angle ☿OC $69^{\circ} 6' 44''$; —side C☿, Mercury's visible latitude
 from the sun, at the time of the first internal contact, 903'',
 $543 = 15' 3'', 543$; which, added to the parallax in latitude
 from the sun, 2'', 837, gives $15' 6'', 38$, for Mercury's true
 latitude by observation, at the time of the first internal contact;
 —the side C☉, the visible difference of longitude of the cen-
 ters of the sun and Mercury, 344'', 809; which, lessened by the
 parallax in longitude from the sun, 2'', 158 gives 342'', 651 for
 the true difference of longitude; which, converted into time,
 gives $58' 9\frac{1}{2}''$. This added to 10^h. 12' 41", A. M. gives 11^h.
 10' 50 $\frac{1}{2}''$, for the apparent time of the true ecliptic conjunc-
 tion.

In $58' 9\frac{1}{2}''$, Mercury's geocentric latitude was increased 50''
 365; which, added to $15' 6'', 38$, his latitude at the first in-
 ternal contact, gives $15' 56'', 745$, for Mercury's true latitude
 by observation, at the time of the true ecliptic conjunction,
 by the internal contacts.

The

The apparent time of the true ecliptic conjunction, by the external contacts, being $11^h 10' 51\frac{1}{4}''$, and by the internal ones $11^h 10' 50\frac{1}{2}''$, let us call the time $11^h 10' 51''$, when Mercury's latitude, by the former, must have been $15' 58''$, 257, and by the latter, $15' 56''$, 752, the mean of which, $15' 57''$, 504, may be called Mercury's true latitude by observation, at the time of the ecliptic conjunction. By M. de la Lande's tables it was $15' 51''$, 524; so that the error in the tables, by this mean, is — $5''$, 98.

For Mercury's heliocentric latitude, according to the observed geocentric latitude.

Mercury's distance from the sun, 31198 : Mercury's distance from the earth 67681 :: Mercury's geocentric latitude at the ecliptic conjunction, by observation, $15' 57''$, 504 = $957''$, 504 : Mercury's heliocent. lat. by observation, $2077''$, 2 = $34' 37''$, 2.

For the place of the ascending node by observation.

Let αE , in Plate II. Fig. IV. be a portion of the ecliptic; the point α the place of φ 's ascending node; $\alpha \varphi$ a portion of φ 's heliocentric orbit; the point at φ his heliocentric place in his orbit, at the time of the ecliptic conjunction, and E his place reduced to the ecliptic; $E \varphi$ his heliocentric latitude; the angle $E \alpha \varphi$ the inclination of his orbit, by modern Astronomers generally determined to be $7^\circ 0' 0''$. In the right-angled spheric triangle $E \alpha \varphi$, right-angled at E, there are given the angle $E \alpha \varphi$, and the perpendicular or side $E \varphi$, to find the base or side αE .

Radius,

: Tang. $E \varphi$ or φ 's heliocentric lat.	$34' 37''$, 2	8 0030458
:: Tang. Co-inclination φ 's orbit,	$83^\circ 0' 0''$	10 9108562
: Sine base αE or φ 's dist. from asc. node,	$4 42 16$	8 9139020

As

As Mercury's heliocentric motion was in the order of the
sines, and he had passed the node, subtract this distance from
his heliocentric longitude, and the remainder will be the point
 Ω of the ecliptic, or place of Mercury's ascending node.

Mercury's heliocentric longitude,	$1^{\text{s}}.20^{\circ}26'36''$
Subtract γ 's distance from Ω ,	<u>4 42 16</u>
Place of γ 's ascending node by observation,	1 15 44 20
Ditto by M. de la Lande's tables,	1 15 45 54



VIII. *Observations of a Solar Eclipse, October 27, 1780, made at St. John's Island, by Messrs. CLARKE and WRIGHT. In a Letter from Mr. JOSEPH PETERS to CALEB GARNET, A. M. Rec. Sec. Amer. Acad.*

Halifax, (Nova-Scotia) 27th August 1781.

S I R,

SOME time in the beginning of this summer, Mr. Winslow shewed me a paragraph of a letter from you, requesting him, if he could, to obtain the minutes of some observations of the eclipse of the sun, which happened the 27th of October, 1780. I am so unfortunate as not to have any kind of apparatus for observations of that sort; nor is there, that I know of, in this place, any thing of the kind,—these things, however useful, as well as pleasing, being very little attended to in this place.

Since the said application from Mr. Winslow, I have received from my friend, Doctor John Clarke, who was educated in your College, some minutes of an observation of the fore-mentioned eclipse, made by himself and a Mr. Wright, at Charlotte-town, on the island of St. John, in the gulph of St. Laurence. I take the liberty to inclose you a copy of them.

Dr. Clarke says, that the observation was made with a reflecting telescope, two feet long, and compleatly fitted for the purpose. A clock was regulated with great accuracy, by means of double altitudes of the sun, taken on several days before and on the day of the eclipse. The observers were deficient only in a micrometer to measure the quantity. They estimated it at 11 digits.

Charlotte-town,

Charlotte-town, by observations of Mr. *Wright*, is in latitude $46^{\circ} 13'$ north, and $62^{\circ} 50'$ west longitude from *London*.

This observation agrees well with the best judgment I could frame of this eclipse, at *Halifax*, by a good watch, regulated by the best time pieces here, to as great exactness as was in my power; except the quantity, which must be something greater here, than at the island. I projected this eclipse to be 11 dig. 30' here, and by the best observations I could make, that was very nearly its real quantity.

I am assured by Mr. *Pool*, of *Yarmouth-Jebouge-Harbour*, on the western coast of this province, that the eclipse there was total for a momentary space.

This, Sir, is the best account I am able to give concerning the phases of this eclipse in these parts; which, if it prove useful in science, or satisfactory to you, I shall think myself happy in having the opportunity of communicating it.

The town of *Halifax*, from observations of Mr. *Desbarres*, is in $44^{\circ} 44'$ north latitude, and $63^{\circ} 30' 30''$ west longitude from *London*.

I am, Sir, your most obedient

And very humble servant,

JOSEPH PETERS.

To Mr. *Caleb Gannett*.

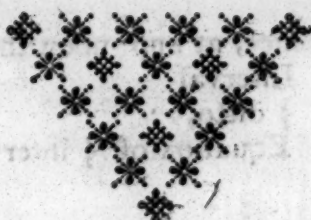
The following are the observations made by Mess^{rs}. *Clarke* and *Wright*:

	App. Time.
Beginning of the eclipse,	11 ^h 41' 35" A.M.
D's southern limb at letter <i>a</i> , Plate II. Fig. V,	11 56' 30"
Ditto in contact with <i>b</i> ,	12 59 20

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	App. time.
δ 's western limb quitted d ;	1 ^h 28' 38" A.M.
Ditto quitted b ,	1 35 13
End of the eclipse,	2 17 41
Duration,	2 36 6

They missed the contacts with c by altering the position of the telescope.



IX. *Observations of a Solar Eclipse, October 27, 1780, made at the University in Cambridge. Communicated by CALEB GANNETT, A. M. Rec. Sec. Amer. Acad.*

ON several days previous to the eclipse, I carefully took corresponding altitudes of the sun, with an excellent *Hadley's* quadrant. The agreement between the observations was such, that those taken on the two immediately preceding days, express the result of the whole. They were as follow :

Oct. 25, A. M.	P. M.		
8h 59' 19"	2h 50' 1"	Hence, at app. noon the clock was	11h 54' 40"
8 56 1	2 53 11	Interval	5 57 40
8 52 10	2 57 18	$\frac{1}{2}$ ditto	2 58 50
		Equation of $\frac{1}{2}$ intervals	+ 16
Sum, 26 47 30	8 40 30		11 54 56
Mean, 8 55 50	2 53 30		
		Clock flow of sun,	5 4
Oct. 26, A. M.	P. M.		
8 48 1	3 1 18	Hence, at app. noon the clock was	11 54 36
8 52 11	2 57 1	Interval	5 56 8 35"
8 56 47	2 52 23	$\frac{1}{2}$ ditto,	2 58 4 18
9 0 58	2 48 11	Equation of $\frac{1}{2}$ interval	+ 16
9 4 42	2 44 29		11 54 52
Sum, 44 42 39	14 23 22		
Mean, 8 56 31 48"	2 52 40 24"	Clock flow of sun,	5 8

On the 27th, observations were taken in the morning ; but the atmosphere was so loaded with vapour, as to prevent the taking of any, with accuracy, in the afternoon.

From the above observations it appears, that between the 25th and 26th of October, the clock gained on mean time 2". Hence, on the 27th, at apparent noon, the clock was flow of the sun 5' 11". Two common brass reflecting telescopes were used upon the occasion, each magnifying about 60 times ; also,

an

an achromatic, made by *Dolland*, it's magnifying power 90. The Reverend Professor *Wigglesworth* and Mr. *John Mellen*, used two of the telescopes. Mr. *Mellen* observed with the achromatic.

The observers were so unfortunate as not to perceive the beginning of the eclipse. They supposed the shadow would have entered the sun's disc more westerly than it did.—They therefore attended to a different part of the sun's limb. To prevent a similar error in future, it might be well, previously, to determine the point at which an eclipse will commence. This may be done by calculating the angle, which the ecliptic will make with a vertical circle passing through the centre of the sun, at the time the eclipse begins.

The observations were as follow, viz.

	Observers, <i>Wigglesworth</i> .	<i>Gannett</i> .	<i>Mellen</i> .	Mean of obs.
	h. ' "	h. ' "	h. ' "	h. ' "
First contact of N. W. spots, } Plate II. Fig. VI.	11 20 57		11 21 3	11 21 0
Total obscuration of ditto,	11 25 15		11 25 36	11 25 25 $\frac{1}{2}$
First cont. of N.E. spots, No. 1,	11 31 36	11 31 53	11 31 38	11 31 42 $\frac{1}{3}$
2,		11 33 4		11 33 4
3,		11 33 54		11 33 54
Total obscuration of	4, 11 34 52		11 34 58	11 34 55
First cont. of central spot,	11 35 26	11 35 30	11 35 30	11 35 28 $\frac{2}{3}$
Total obscuration of ditto,	11 36 19	11 36 4	11 36 14	11 36 12 $\frac{1}{3}$
First cont. of S. E. spot,		12 13 47	12 13 47	12 13 47
Total obscuration of ditto,		12 14 3	12 14 4	12 14 3 $\frac{1}{2}$
Total emerfion of N. W. spots,	12 29 28			12 29 28
First app. of N.E. spots, No. 1,	12 52 56	12 52 33	12 52 31	12 52 36 $\frac{2}{3}$
2,		12 53 27		12 53 27
3,		12 54 9		12 54 9
Total emerfion of	4, 12 55 23		12 56 4	12 55 43 $\frac{1}{2}$
First app. of central spot,		12 56 11		12 56 11
Total emerfion of ditto,	12 56 47	12 56 45		12 56 46
First app. of S. E. spot,		1 33 51	1 33 47	1 33 49
Total emerfion of ditto,	1 34 1	1 34 5		1 34 3
End of the eclipse,	1 39 51	1 39 47	1 39 50	1 39 49 $\frac{1}{3}$
Digits eclipsed, about 11 $\frac{2}{3}$.				

The observers not being possessed of a micrometer, Mr. *Wigglesworth* made use of the following expedient to determine

the quantity of the eclipse.—He described on paper a number of circles, dividing a common diameter into digits. The paper was placed perpendicular to a telescope, through which the sun's rays were received upon it. Accuracy is not pretended in this method. The quantity noted, is the nearest that could be estimated by it.

Through want of cross wires in either of the telescopes used, the precise situation of the spots, on the sun's disc, could not be determined. In the figure, their relative situation is marked, according to judgment at the time.



X. *An Observation of a Solar Eclipse, October 27, 1780, at Providence. By JOSEPH BROWN, Esquire.*

MY apparatus for the observation of the solar eclipse was a three-feet reflecting telescope, with spirit levels; a small graduated semi-circle of about $4\frac{1}{2}$ inches radius, and rack motions for taking altitudes; and a glass micrometer, fitted with rack motions, I believe of *Dolland's* construction, having a nonius graduated to $\frac{1}{500}$ part of an inch: A reflecting telescope of near two feet; and a prospect-glass of three feet four inches length, which I mounted on a convenient stand.

On the 20th, I moved my clock into a convenient part of my house; and from that time to the day of the eclipse, I was constantly employed in taking corresponding altitudes of the sun with my telescope, and constructing a meridian-line.

Our observations of the eclipse were as follow:

The beginning was not accurately noted.

First seen in correct time, 10^h. 58' 8"

Just touches a black spot in or near the middle of a macula at the right hand, 11 21 32

Just touches the first of four spots all nearly in a range in a macula at the left hand, 11 30 52

Ditto the spot nearest the centre of the sun's disc, 11 35 20

The end of the eclipse as seen by Mr. *West* in the small telescope, 1 39 1

Ditto by my brother in the spy-glass, 1 39 8

Ditto last seen by myself in the largest reflector, 1 39 16

I took the diameter of the sun while the eclipse was on, and made it three inches and $\frac{434}{1000}$; which, by my table, constructed in the year 1769, previous to the transit of Venus, makes the sun's apparent diameter $32' 18''$: And the smallest I saw the bright part of the sun was $\frac{140}{1000}$ of an inch: So small I am certain it was, and it might probably be a very little less, tho' I believe this to be pretty exact; and this, I think, makes the sun to be 11 digits and $\frac{3}{10}$ eclipsed, or very nearly so.



XI. *Observations of the Solar Eclipse of the 27th of October, 1780, made at Newport, Rhode-Island, by Mons. de GRAN-CHAIN. Translated from the French, and communicated by the Reverend President WILLARD.*

	Times per Clock.			True Times.		
	h.	'	"	h.	'	"
THE instant when it was perceived that the eclipse had begun,*	9	24	32	11	0	12
Preceding limb of the sun at the vertical,	11	21	39	0	57	27
Upper limb of the sun at the horizontal,	21	54		57	42	
Upper horn at the horizontal,	22	3		57	51	
Limb of the moon at the vertical,	22	45		58	33	
Upper horn at the vertical,	23	7		58	55	
Lower horn at the vertical, doubtful,	23	35		59	23	
Lower horn at the horizontal,	29	31		1	5	20
Lower limb of the sun at the horizontal,	31	2		6	51	
Preceding limb of the sun at the vertical,	11	37	12	1	13	1
Upper limb of the sun at the horizontal,	37	59		13	48	
Upper horn at the horizontal,	38	32		14	21	
Limb of the moon at the vertical,	passed,					
Upper horn at the vertical,	38	57		14	46	
Lower horn at the vertical,	39	19		15	8	
Lower horn at the horizontal,	43	38		19	28	
Lower limb of the sun at the horizontal,	45	27		21	17	

N. B. The apparent upper and lower limb of the planet, in the telescope of the quadrant, which inverts objects, is here called the upper and lower limb.

Preceding

* When it was perceived that an impression was made upon the limb of the sun, the eclipse had been begun 1' 20"; therefore, the true beginning was at 10 58' 52".

Preceding limb of the sun at the vertical,	11 ^h 47' 8"	1 ^h 22' 58"
Upper limb of the sun at the horizontal,	48 17	24 7
Limb of the moon at the vertical,	49 0	24 50
Upper horn at the vertical,	49 5	24 55
Upper horn at the horizontal,	49 7	24 57
Lower horn at the vertical,	49 21	25 11
Lower horn at the horizontal,	52 52	28 42
Lower limb of the sun at the horizontal,	55 2	30 52
End of the eclipse,	0 4 50	1 40 41
Latitude of the observatory upon <i>Goat-Island</i> ,		41° 30' 30"

Observations of the lunar eclipse of the 11th of Nov. 1780,
made at *Newport*, (*Rhode-Island*.) By *Monf. de GRAN-*
CHAIN.

	Times per Clock.	True Times.
Beginning of the eclipse,	7 ^h 40' 5"	10 ^h 24' 39"
Beginning of the immersion of <i>Grimaldus</i> ,	48 50	33 25
End of the immersion of <i>Grimaldus</i> ,	51 25	36 10
Beginning of the immersion of <i>Tycho</i> ,	8 0 36	10 45 12
The shadow of <i>Galileo</i> ,	3 42	48 18
Beginning of the immerf. of <i>Copernicus</i> ,	27 54	11 12 31
End of the immersion of <i>Copernicus</i> ,	32 35	17 12
The shadow at the middle of <i>Dionysius</i> ,	46 55	31 33
The shadow at <i>Promontorium acutum</i> ,	55 42	40 21
<i>Copernicus</i> begins to emerge,	9 17 54	12 2 34
<i>Grimaldus</i> begins to emerge,	22 2	6 42
<i>Copernicus</i> wholly emerges,	23 35	8 15
<i>Grimaldus</i> wholly emerges,	26 45	11 26
<i>Promontorium acutum</i> emer. from the shad.	51 12	35 55
<i>Tycho</i> wholly emerges from the shadow,	10 10 6	54 51
End of the eclipse,	32 10	1 16 57
		The

The same clock and quadrant were made use of in this observation, which had been used for the observation of the solar eclipse. The going of the clock was, however, a little different, because it had been altered.

ILLUSTRATIONS OF THE OBSERVATION OF THE SOLAR ECLIPSE.

The clock which was made use of to obtain the times, had a compound pendulum-rod, made by *Monf. Bertboud*, a celebrated clock-maker at *Paris*. It was regulated many days before and after the observation, by corresponding altitudes, taken with a quadrant made by *Ramsden*, which was very good and very well divided.

The same quadrant was used in observing the transits of the horns, and of the limbs of the sun and of the moon, across the horizontal and vertical wires of the telescope, which was fitted for this purpose.

The observer, who, in putting on board the astronomical instruments, had nothing in view but the regulation of marine watches, was not so well provided with telescopes, as with time-pieces and quadrants. To observe the beginning and end of the eclipse, he was obliged to make use of a simple achromatic sea-glass, of three and an half feet focus. However, he believes he may answer for the end of the eclipse, within four or five seconds nearly. The instant of the beginning is much more uncertain. A considerable impression was made upon the sun, before it was perceived. To determine, at least, roughly, the true instant of the beginning of the eclipse, an estimation was made, as near as might be, of the distance of the horns, at the moment when it was perceived that an impression

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was

was made upon the disc of the sun ; and towards the end of the eclipse, it was observed how much time passed from the instant when the distance of the horns was sensibly the same, to the end of the eclipse. It is in this manner that it was determined, that about 1' 20" must have intervened, between the true instant of the beginning of the eclipse, and the time when the impression was first observed.

At first it was thought useless to endeavour to observe the quantity of the eclipse with the quadrant, because of the slowness of the motion of the two planets vertically ; however, upon reflection, it was thought that the transits of the horns, and of the limbs of the sun and moon across the vertical wire only, would be sufficient to give the differences of the altitudes and azimuths of the centers of the two planets, and, consequently, their differences of latitude and longitude. These were, therefore, observed towards the end of the eclipse, and at the same time, the transits across the horizontal wire were observed, but without hoping that they could be of any great advantage, for calculating the distance of the centers.

In the first observation, the transit of the apparent lower horn across the horizontal wire is a little doubtful : It may therefore be proper to prefer, in the calcule from this observation, the transit of the limb of the moon, and of the apparent upper horn, across the same vertical wire.

In the second observation, the instant of the transit of the limb of the moon across the vertical wire was omitted, through hurry :—To calculate it, therefore, we may make use of the transit of the horn across the same wire.

The last observation, being more complete, we may calculate it by the one or the other method, indifferently ; or we
may

may make use of the transits across the horizontal wire, to deduce the difference of altitude, because the motion of the two planets, vertically, was become less slow, when this observation was made.

If we would, in the first observation, verify the instant of the transit of the apparent lower horn across the vertical wire, or know, in the second observation, the instant of the transit of the limb of the moon across the same wire, we may easily calculate them, with the assistance of the quantities already known. It will, perhaps, be useful to make this calculation, that we may be in a condition of determining the variation, which must have taken place, in the position of the two planets, observed relatively the one to the other, during the space of time which intervened, between their transits across the same wire.



XII. *An Account of the Observations made in Providence, in the State of Rhode-Island, of the Eclipse of the Sun, which happened the 23d Day of April, 1781.* By BENJAMIN WEST, Esquire, F. A. A. Communicated by the Reverend President WILLARD.

I HAVE thought proper to draw up a particular account of this eclipse, as well knowing that proper observations of eclipses make an important article in the theory of astronomy. It was by these kind of observations the lunar theory was bro't to it's present degree of perfection : And every Astronomer knows of what consequence it is to navigation, to have the moon's motion settled to a certain degree of accuracy.

This eclipse was observed in *Providence* by Mr. *Joseph Brown* and myself, at Mr. *Brown's* house. The morning of the 23d of April was cloudy, and I despaired of seeing the sun that day ; but a little before twelve o'clock, the clouds seemed to break, and the sun, now and then, made it's appearance, which gave me some hopes of seeing some part of the eclipse : But after twelve o'clock the sun was again obscured by the clouds, and remained so till five or six minutes after the first contact of the sun's and moon's limb, when we had again a slight view of the sun through the clouds, and saw the eclipse was coming on. The air continued unfavourable to our observation till a few minutes before the middle of the eclipse, when the sun again appeared, and gave us a good opportunity of observing the quantity of the eclipse when at the greatest ;—for which purpose, Mr. *Brown* applied the micrometer, and found the lucid part of the sun, when in its least state, 1288 microme-

ter

ter measure. This was not done at a single operation, but by a number of trials, till he found the bright part of the sun was in it's least state. After reading off the numbers from the micrometer for the quantity of the eclipse, Mr. *Brown* immediately, at my request, took the length of the chord joining the cusps, which I believe was done with great care, and found it 1380. The micrometer measures for the sun's diameter was 1906. Then $1906 - 1288 = 618$, the eclipsed part, and $\frac{618 \times 12}{1906} = 3^\circ 53'$ digits for the greatest quantity of the eclipse. From the table which we made for the micrometer in the year 1769, the sun's apparent diameter was $31' 53''$, exactly agreeing with what *Mayer's* tables make it. I found the apparent diameter of the moon by the following method:—Let GFI be the sun, and HEB the moon, and EF the chord joining the sun's cusps. Now, as BG is a straight line, bisecting the straight EF at right-angles, it must therefore pass through the centers both of the sun and moon. (*Euclid* 1. III.) The angle ADE is a right-angle, and AE and ED are given quantities. Then $\sqrt{AE^2 - DE^2} = AD$. (Per *Euclid* 47. I.)

$$AE = 953$$

$$DE = 690$$

$$\text{Sum} = 1643 \quad 3.2156376$$

$$\text{Difference} = 263 \quad 2.4199557$$

$$2) 5.6355933$$

$$AD = 657,2 \quad 2.8177966$$

$$AG = 953$$

$$DG = 1610,2$$

$$GH = 1288$$

$$HD = 322,3$$

The

The angle BEH, in a semi-circle, is a right-angle, (*Euc.* 31. III.) and HD, DE, DB, are three proportionals, (*Euc.* 8. VI.) that is to say, $HD : DE :: ED : DB$.

$$DE = 690 \quad 2.8388491$$

x 2

$$HD \quad 322,3 \quad \begin{array}{r} 5.6776982 \\ 2 \quad 5082603 \end{array}$$

$$BD = 1477,2 \quad 3 \quad 1694379$$

HB = 1299,5 the micrometer measure for the moon's diameter. It is a thing well known to mathematicians, that the fines of small arcs are nearly equal to the arcs themselves; hence we have a rule to find the moon's apparent diameter by proportions.

☉'s micrometer measure 1906,

Log. 3 2801

It's $\angle$, $31' 53''$,

LL 7517

☽'s micrometer measure 1799,5

6° ar. 6 7449

☽'s apparent diameter, $30' 6''$,

LL 7767

Deduct — 23 for the moon's elevation.

☽'s horizontal diam. 29 43, but one second more than what is given from *Mayer's* tables.

Mr. *Brown* and myself both noted the same second for the last contact, which was at $2^h 53' 36''$ apparent time. There were some thin white clouds about the sun, yet I think the observation was pretty good.



XIII. *Account of the Transit of Mercury, observed at Cambridge, November 12, 1782. By JAMES WINTHROP, Esquire, F. A. A.*

THE following observations were made at the house of the Reverend Professor *Williams*. We used the same clock, but observed the transit from different parts of the house. The clock was regulated by the Professor, who reduced all the observations to apparent time. Mine were as follow :

First external contact,	10 ^h 6' 31" A. M.
First internal contact when the thread of light was formed, and Mercury recovered his roundness,	10 12 13
Mercury begun to appear oblong before the second internal contact,	11 21 41
Doubtful whether the thread of light was broken,	11 22 44
Second internal contact when the thread of light was compleatly broken,	11 23 5
Second external contact,	11 29 19

The magnifying power of the reflecting telescope used in these observations, was 260. The elliptical appearance of the planet was observed by Mr. *Williams* as well as myself, at both passages over the sun's limb; but I do not recollect to have seen it remarked of any former transit of this planet. An idea that the smallness of Mercury's apparent diameter and the rapidity of his motion would not suffer it to be of any long continuance, prevented my making more particular remarks at the time of the ingress. The certainty of a sufficient interval between

tween the last contacts, enabled me to attend more particularly to this observation at the end, than at the beginning of the transit. At $11^h 21' 41''$ apparant time, Mercury began to appear distorted; and from this time the thread of light grew gradually fainter till $11^h 22' 44''$, when I was doubtful whether it existed any longer. I set down the second internal contact at $11^h 23' 5''$, when I was first certain that the thread of light was broken. From the time that the center of the planet appeared to me to have passed the sun's limb, the appearance of it's following half became very irregular, being disturbed by a brisk undulatory motion, which continued till the end of the transit.

This distortion appears to be common to both the inferior planets, when in the same situation with respect to the observer. At the transit of Venus in 1761, it was observed in *India*, *England* and *Sweden*; and at that of 1769, by almost all who observed the transit. They indeed vary in their ideas of its duration; which cannot be wondered at when we consider the different magnifying power of their instruments, and the different strength of their eyes. Particular descriptions of the appearance of Venus, in her two transits, are published in Vols. LIX. LX. and LXI. of the Philosophical Transactions, with suitable projections; and from the great resemblance they bear to the appearance of Mercury in his last transit, the conclusion is natural that they arose from the same cause.

The object is so small and remote, that we can hardly expect to determine it's cause with absolute certainty. It will not, however, be deemed amiss to remark, as a *probable* cause only, that the rays proceeding from so small an object as that part of the sun's limb which is nearest to the planet, during the distortion of the latter, are too feeble to make a full impression.

pression on the seat of vision. Objects seen by reflection, as most terrestrial bodies are, cannot be seen distinctly, unless they subtend a certain angle. The same thing taking place in luminous objects, with a smaller angle, when the thread of light becomes too small to be distinctly seen, the exterior limb of the planet will appear confused; and every degree of confusion, arising from a partial defect of light, will operate upon the eye like a real distortion of the object. If this opinion be right, as the distance of centers is easily calculated for any given moment, perhaps the limits of vision, as far as respects luminous objects, may be ascertained by accurate observations of this kind.

Cambridge, 27th December, 1783.



W

Apparent

XIV. *Observations of an Eclipse of the Moon, March 29, 1782, and of an Eclipse of the Sun, on the 12th of April following, at Ipswich, Lat. $42^{\circ} 38' 30''$. By the Reverend MANASSEH CUTLER, F. A. A.*

IN the following observations I made use of a reflecting telescope, made by *Mann*, magnifying 45 times. My clock was carefully regulated by taking corresponding double altitudes of the sun, reflected from a bowl of the oil of tar, with *Hadley's* quadrant.

The night of 29th of March was exceedingly clear, and the atmosphere very free from vapour. At $2^h 15' 1''$ apparent time, I observed a dusky appearance on the part of the moon's limb, which was then just within the lower part of the field of my telescope; and, bringing it instantly into the center of the field of view, found the penumbra considerably advanced, and in about $42''$ perceived an impression from the shadow.

Apparent Time.

At $2^h 15' 1''$ discovered the penumbra somewhat advanced.

2 15 42 eclipse began.

2 21 17 in contact with *Gasseudus*.

2 25 37 in contact with *Mare Humorum*.

2 30 31 in contact with *Tycho*.

2 33 30 in contact with *Grimaldus*.

2 34 35 in contact with *Pitatus*.

2 40 11 *Grimaldus* covered.

2 54 55 in contact with *Snellius et Furnerius*.

3 2 1 in contact with *Keplerus*.

3 10 23 *Dionysius* covered.

3 14 2 *Promontorium Acutum Censorinus* covered.

Apparent

Apparent Time.

- At 3^h 24' 13" *Manilins* covered.
 3 26 39 *Plinius* covered.
 3 31 9 in contact with *Mare Crisium*.
 3 40 20 *Grimaldus* begins to emerge.
 3 53 54 emerfion of *Manilins* and *Plinius*.
 4 45 40 emerfion of *Mare Nectaris*.
 4 51 25 emerfion of *Snellius et Furnerius*.
 4 55 20 eclipse ends.
 4 57 5 day-light fo far advanced that the penumbra
 could no longer be perceived.

On the 12th of April I was favoured with the company of the Reverend Mr. *Prince*, of *Salem*, and Mr. *Brown Emerson*, of *Reading*, who observed the eclipse with me. Mr. *Prince* made use of a reflecting telescope, the magnifying power not known, but supposed to be about 45. Mr. *Emerson* observed with a reflector, made by *Mann*, magnifying 34 times.

The day was fine, and the sky unusually clear in the morning; but before twelve o'clock the sun was frequently covered with detached flying clouds. Just at the time the eclipse began, however, the sun was free from any cloud and excellently defined. I was so fortunate as to have the point in the sun's limb, where the contact took place, full in the field of view, and noted the second that was called when I first suspected an impression, though I was not certain of the contact for the space of two or three seconds after. Before the eclipse ended, the wind breezed up fresh, and the vapour increased so as to occasion a constant undulation of the sun's limb. We were, therefore, not so certain about the time of the ending, as we were of the beginning of the eclipse.

W 2

Mr.

Mr. Prince. Mr. Emerson. Myself.

Beginning,	oh 12' 52"	oh 12' 48"	oh 12' 46"	} Apparent time.
End,	2 53 19	2 53 6	2 53 15	
Duration,	2 40 27	2 40 18	2 40 29	

The latitude of my house has been found, by the mean of about twenty double altitudes of the sun, when on the meridian, taken with an *Hadley's* quadrant, to be $42^{\circ} 38' 30''$.



XV. *On the Extraction of Roots.* By BENJAMIN WEST,
Esquire, F. A. A. In a Letter to Mr. CALEB GAN-
NETT, Rec. Sec. F. A. A.

DEAR SIR,

HAVING a little leisure at this time, I thought it a proper opportunity to fulfil my promise of sending you the substance of what I have done, respecting the Roots. What I chiefly aimed at was, to render the method of extracting the roots of the odd powers easier, and less burthenfome to the memory; and, I think, I have not failed in my attempt. The method, followed by *Ward* and others, is excellent, but is attended with too much difficulty in getting the divisors; especially for learners, who are not acquainted with the reason of the rules.—That difficulty I have strove to remedy in the following work. In the course of my teaching, since I made this discovery, I have not met with more trouble in teaching the third, fifth and seventh powers, than what is usual in extracting the square root. Methods, similar to these, may be found for extracting the roots of the even powers.

I generally get the three first figures in the root by the first operation, (if there are so many in the root) tho' many times four or five may be got, if the first figure in the root comes very near to the first period of the resolvend.

As it is not necessary to make a long introduction, I shall proceed to show in what manner I investigated the rules. The cube root being the first in order, I shall begin with that; and in order thereto, let the resolvend be $= a$; the first figure in the root $= r$; and the remaining figures in the root $= e$; and

then

then the root will be $r + e$; and, by involution $r^3 + 3r^2e + 3re^2 + e^3 = a$. By dropping e^3 , and making the other terms equal to a , we shall have $r^3 + 3r^2e + 3re = a$; and by subtraction $3re^2 + 3re^2 = a - r^3$; and by division $e^2 + re = \frac{a - r^3}{3r}$; and by completing the square, we shall have $e^2 + re + \frac{r^2}{4} = \frac{a - r^3}{3r} + \frac{r^2}{4} = \frac{4a - r^3}{12r}$; by extracting the square root of both sides, it will give $e + \frac{r}{2} = \sqrt{\frac{4a - r^3}{12r}}$; whence $e = -\frac{r}{2} + \sqrt{\frac{4a - r^3}{12r}}$; and by the addition of r on each side, it will be $r + e = r - \frac{r}{2} + \sqrt{\frac{4a - r^3}{12r}} = \frac{r}{2} + \sqrt{\frac{4a - r^3}{12r}}$. From which comes this rule:

Take the nearest root to the first period of the resolvend, be it more or less than just, and supply it with as many cyphers as there are remaining periods in the resolvend, and call it the assumed root. Then multiply the given resolvend by 4; from the product subtract the cube of the assumed root; divide the remainder by 12 times the assumed root, and extract the square root of the quotient. To the square root, thus found, add one half of the assumed root, and it will give the cube root corrected; which may be repeated and carried to what exactness you may wish to have it;—always taking the last root for the assumed root.

Take an example or two.—Let it be required to extract the cube root from 735051274. Here 9 is the nearest root 735, and 900 is the assumed root, less than just.

735051274

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$$\begin{array}{r}
 735051274 \text{ (900 = assumed root.} \\
 \times 4 \\
 \hline
 2940205096 \\
 900 = \text{---} 729000000 \\
 \hline
 900 \times 12 = 10800 \quad 2211205096 \text{ (204741} \\
 216 \dots\dots
 \end{array}$$

$ \begin{array}{r} 512 \\ 432 \\ \hline 800 \\ 756 \\ \hline 445 \\ 432 \\ \hline 130 \\ 108 \\ \hline 22 \end{array} $	$ \begin{array}{r} 4 \\ 4 \\ \hline 85 \\ 5 \\ \hline 902 \end{array} $	$ \begin{array}{r} 204741 \text{ (452,} \\ 16 \quad 450 = \text{the assumed root.} \\ \hline 447 \quad 902 = \text{true root, nearly.} \\ 425 \\ \hline 2241 \\ 1804 \\ \hline 437 \end{array} $
---	---	---

Take a second example. Extract the cube root from 330625.

330625 (70 = assumed root, more than just.

$$\begin{array}{r}
 1322500 \\
 70 = \text{---} 343000 \\
 \hline
 70 \times 12 = 840 \quad 979500 \text{ (1166, 07 (34, 1} \\
 84 \dots 3 \quad 9 \quad 35 = \frac{1}{2} 70 \\
 \hline
 139 \quad 3 \quad 266 \quad 69, 1 \text{ corrected.} \\
 84 \quad 64 \quad 256 \\
 \hline
 555 \quad 1007 \\
 504 \quad 681 \quad 681 \\
 \hline
 510 \quad 326 \\
 504 \\
 \hline
 600 \\
 588 \\
 \hline
 12
 \end{array}$$

The work repeated,

$$\begin{array}{r}
 69, 1 \\
 69, 1 \\
 \hline
 691 \\
 6219 \\
 4146 \\
 \hline
 4774, 81 \text{ square.} \\
 69, 1 \\
 \hline
 2864886 \\
 429733 \\
 4774 \\
 \hline
 329939, 3 \text{ cube.}
 \end{array}$$

Let x = the required root. Then $x^3 = 330625$.
 $x^3 = 330625$
 $x = \sqrt[3]{330625}$
 $x = 70$
 $70^3 = 343000$
 $343000 - 330625 = 12375$
 $12375 \div 70 = 176, 75$
 $70 + 176, 75 = 246, 75$
 $246, 75^3 = 15116580, 375$
 $15116580, 375 - 330625 = 14785955, 375$
 $14785955, 375 \div 246, 75 = 59, 93$
 $246, 75 + 59, 93 = 306, 68$
 $306, 68^3 = 289939, 3$
 $289939, 3 - 330625 = 256814, 3$
 $256814, 3 \div 306, 68 = 836, 25$
 $306, 68 + 836, 25 = 1142, 93$
 $1142, 93^3 = 1492839, 3$
 $1492839, 3 - 330625 = 1162214, 3$
 $1162214, 3 \div 1142, 93 = 1017, 25$
 $1142, 93 + 1017, 25 = 2160, 18$
 $2160, 18^3 = 10000000$
 $10000000 - 330625 = 9669375$
 $9669375 \div 2160, 18 = 4476, 25$
 $2160, 18 + 4476, 25 = 6636, 43$
 $6636, 43^3 = 292839, 3$
 $292839, 3 - 330625 = 259774, 3$
 $259774, 3 \div 6636, 43 = 391, 25$
 $6636, 43 + 391, 25 = 7027, 68$
 $7027, 68^3 = 347839, 3$
 $347839, 3 - 330625 = 17214, 3$
 $17214, 3 \div 7027, 68 = 2, 43$
 $7027, 68 + 2, 43 = 7030, 11$
 $7030, 11^3 = 347839, 3$
 $347839, 3 - 330625 = 17214, 3$
 $17214, 3 \div 7030, 11 = 2, 43$
 $7030, 11 + 2, 43 = 7032, 54$
 $7032, 54^3 = 34839, 3$
 $34839, 3 - 330625 = 17714, 3$
 $17714, 3 \div 7032, 54 = 2, 54$
 $7032, 54 + 2, 54 = 7035, 08$
 $7035, 08^3 = 34939, 3$
 $34939, 3 - 330625 = 18314, 3$
 $18314, 3 \div 7035, 08 = 2, 58$
 $7035, 08 + 2, 58 = 7037, 66$
 $7037, 66^3 = 35039, 3$
 $35039, 3 - 330625 = 19414, 3$
 $19414, 3 \div 7037, 66 = 2, 66$
 $7037, 66 + 2, 66 = 7040, 32$
 $7040, 32^3 = 35139, 3$
 $35139, 3 - 330625 = 20014, 3$
 $20014, 3 \div 7040, 32 = 2, 72$
 $7040, 32 + 2, 72 = 7043, 04$
 $7043, 04^3 = 35239, 3$
 $35239, 3 - 330625 = 20614, 3$
 $20614, 3 \div 7043, 04 = 2, 76$
 $7043, 04 + 2, 76 = 7045, 80$
 $7045, 80^3 = 35339, 3$
 $35339, 3 - 330625 = 21214, 3$
 $21214, 3 \div 7045, 80 = 2, 80$
 $7045, 80 + 2, 80 = 7048, 60$
 $7048, 60^3 = 35439, 3$
 $35439, 3 - 330625 = 21814, 3$
 $21814, 3 \div 7048, 60 = 2, 84$
 $7048, 60 + 2, 84 = 7051, 44$
 $7051, 44^3 = 35539, 3$
 $35539, 3 - 330625 = 22414, 3$
 $22414, 3 \div 7051, 44 = 2, 88$
 $7051, 44 + 2, 88 = 7054, 32$
 $7054, 32^3 = 35639, 3$
 $35639, 3 - 330625 = 23014, 3$
 $23014, 3 \div 7054, 32 = 2, 92$
 $7054, 32 + 2, 92 = 7057, 24$
 $7057, 24^3 = 35739, 3$
 $35739, 3 - 330625 = 23614, 3$
 $23614, 3 \div 7057, 24 = 2, 96$
 $7057, 24 + 2, 96 = 7060, 20$
 $7060, 20^3 = 35839, 3$
 $35839, 3 - 330625 = 24214, 3$
 $24214, 3 \div 7060, 20 = 3, 00$
 $7060, 20 + 3, 00 = 7063, 20$
 $7063, 20^3 = 35939, 3$
 $35939, 3 - 330625 = 24814, 3$
 $24814, 3 \div 7063, 20 = 3, 04$
 $7063, 20 + 3, 04 = 7066, 24$
 $7066, 24^3 = 36039, 3$
 $36039, 3 - 330625 = 25414, 3$
 $25414, 3 \div 7066, 24 = 3, 08$
 $7066, 24 + 3, 08 = 7069, 32$
 $7069, 32^3 = 36139, 3$
 $36139, 3 - 330625 = 26014, 3$
 $26014, 3 \div 7069, 32 = 3, 12$
 $7069, 32 + 3, 12 = 7072, 44$
 $7072, 44^3 = 36239, 3$
 $36239, 3 - 330625 = 26614, 3$
 $26614, 3 \div 7072, 44 = 3, 16$
 $7072, 44 + 3, 16 = 7075, 60$
 $7075, 60^3 = 36339, 3$
 $36339, 3 - 330625 = 27214, 3$
 $27214, 3 \div 7075, 60 = 3, 20$
 $7075, 60 + 3, 20 = 7078, 80$
 $7078, 80^3 = 36439, 3$
 $36439, 3 - 330625 = 27814, 3$
 $27814, 3 \div 7078, 80 = 3, 24$
 $7078, 80 + 3, 24 = 7082, 04$
 $7082, 04^3 = 36539, 3$
 $36539, 3 - 330625 = 28414, 3$
 $28414, 3 \div 7082, 04 = 3, 28$
 $7082, 04 + 3, 28 = 7085, 32$
 $7085, 32^3 = 36639, 3$
 $36639, 3 - 330625 = 29014, 3$
 $29014, 3 \div 7085, 32 = 3, 32$
 $7085, 32 + 3, 32 = 7088, 64$
 $7088, 64^3 = 36739, 3$
 $36739, 3 - 330625 = 29614, 3$
 $29614, 3 \div 7088, 64 = 3, 36$
 $7088, 64 + 3, 36 = 7092, 00$
 $7092, 00^3 = 36839, 3$
 $36839, 3 - 330625 = 30214, 3$
 $30214, 3 \div 7092, 00 = 3, 40$
 $7092, 00 + 3, 40 = 7095, 40$
 $7095, 40^3 = 36939, 3$
 $36939, 3 - 330625 = 30814, 3$
 $30814, 3 \div 7095, 40 = 3, 44$
 $7095, 40 + 3, 44 = 7098, 84$
 $7098, 84^3 = 37039, 3$
 $37039, 3 - 330625 = 31414, 3$
 $31414, 3 \div 7098, 84 = 3, 48$
 $7098, 84 + 3, 48 = 7102, 32$
 $7102, 32^3 = 37139, 3$
 $37139, 3 - 330625 = 32014, 3$
 $32014, 3 \div 7102, 32 = 3, 52$
 $7102, 32 + 3, 52 = 7105, 84$
 $7105, 84^3 = 37239, 3$
 $37239, 3 - 330625 = 32614, 3$
 $32614, 3 \div 7105, 84 = 3, 56$
 $7105, 84 + 3, 56 = 7109, 40$
 $7109, 40^3 = 37339, 3$
 $37339, 3 - 330625 = 33214, 3$
 $33214, 3 \div 7109, 40 = 3, 60$
 $7109, 40 + 3, 60 = 7113, 00$
 $7113, 00^3 = 37439, 3$
 $37439, 3 - 330625 = 33814, 3$
 $33814, 3 \div 7113, 00 = 3, 64$
 $7113, 00 + 3, 64 = 7116, 64$
 $7116, 64^3 = 37539, 3$
 $37539, 3 - 330625 = 34414, 3$
 $34414, 3 \div 7116, 64 = 3, 68$
 $7116, 64 + 3, 68 = 7120, 32$
 $7120, 32^3 = 37639, 3$
 $37639, 3 - 330625 = 35014, 3$
 $35014, 3 \div 7120, 32 = 3, 72$
 $7120, 32 + 3, 72 = 7124, 04$
 $7124, 04^3 = 37739, 3$
 $37739, 3 - 330625 = 35614, 3$
 $35614, 3 \div 7124, 04 = 3, 76$
 $7124, 04 + 3, 76 = 7127, 80$
 $7127, 80^3 = 37839, 3$
 $37839, 3 - 330625 = 36214, 3$
 $36214, 3 \div 7127, 80 = 3, 80$
 $7127, 80 + 3, 80 = 7131, 60$
 $7131, 60^3 = 37939, 3$
 $37939, 3 - 330625 = 36814, 3$
 $36814, 3 \div 7131, 60 = 3, 84$
 $7131, 60 + 3, 84 = 7135, 44$
 $7135, 44^3 = 38039, 3$
 $38039, 3 - 330625 = 37414, 3$
 $37414, 3 \div 7135, 44 = 3, 88$
 $7135, 44 + 3, 88 = 7139, 32$
 $7139, 32^3 = 38139, 3$
 $38139, 3 - 330625 = 38014, 3$
 $38014, 3 \div 7139, 32 = 3, 92$
 $7139, 32 + 3, 92 = 7143, 24$
 $7143, 24^3 = 38239, 3$
 $38239, 3 - 330625 = 38614, 3$
 $38614, 3 \div 7143, 24 = 3, 96$
 $7143, 24 + 3, 96 = 7147, 20$
 $7147, 20^3 = 38339, 3$
 $38339, 3 - 330625 = 39214, 3$
 $39214, 3 \div 7147, 20 = 4, 00$
 $7147, 20 + 4, 00 = 7151, 20$
 $7151, 20^3 = 38439, 3$
 $38439, 3 - 330625 = 39814, 3$
 $39814, 3 \div 7151, 20 = 4, 04$
 $7151, 20 + 4, 04 = 7155, 24$
 $7155, 24^3 = 38539, 3$
 $38539, 3 - 330625 = 40414, 3$
 $40414, 3 \div 7155, 24 = 4, 08$
 $7155, 24 + 4, 08 = 7159, 32$
 $7159, 32^3 = 38639, 3$
 $38639, 3 - 330625 = 41014, 3$
 $41014, 3 \div 7159, 32 = 4, 12$
 $7159, 32 + 4, 12 = 7163, 44$
 $7163, 44^3 = 38739, 3$
 $38739, 3 - 330625 = 41614, 3$
 $41614, 3 \div 7163, 44 = 4, 16$
 $7163, 44 + 4, 16 = 7167, 60$
 $7167, 60^3 = 38839, 3$
 $38839, 3 - 330625 = 42214, 3$
 $42214, 3 \div 7167, 60 = 4, 20$
 $7167, 60 + 4, 20 = 7171, 80$
 $7171, 80^3 = 38939, 3$
 $38939, 3 - 330625 = 42814, 3$
 $42814, 3 \div 7171, 80 = 4, 24$
 $7171, 80 + 4, 24 = 7176, 04$
 $7176, 04^3 = 39039, 3$
 $39039, 3 - 330625 = 43414, 3$
 $43414, 3 \div 7176, 04 = 4, 28$
 $7176, 04 + 4, 28 = 7180, 32$
 $7180, 32^3 = 39139, 3$
 $39139, 3 - 330625 = 44014, 3$
 $44014, 3 \div 7180, 32 = 4, 32$
 $7180, 32 + 4, 32 = 7184, 64$
 $7184, 64^3 = 39239, 3$
 $39239, 3 - 330625 = 44614, 3$
 $44614, 3 \div 7184, 64 = 4, 36$
 $7184, 64 + 4, 36 = 7189, 00$
 $7189, 00^3 = 39339, 3$
 $39339, 3 - 330625 = 45214, 3$
 $45214, 3 \div 7189, 00 = 4, 40$
 $7189, 00 + 4, 40 = 7193, 40$
 $7193, 40^3 = 39439, 3$
 $39439, 3 - 330625 = 45814, 3$
 $45814, 3 \div 7193, 40 = 4, 44$
 $7193, 40 + 4, 44 = 7197, 84$
 $7197, 84^3 = 39539, 3$
 $39539, 3 - 330625 = 46414, 3$
 $46414, 3 \div 7197, 84 = 4, 48$
 $7197, 84 + 4, 48 = 7202, 32$
 $7202, 32^3 = 39639, 3$
 $39639, 3 - 330625 = 47014, 3$
 $47014, 3 \div 7202, 32 = 4, 52$
 $7202, 32 + 4, 52 = 7206, 84$
 $7206, 84^3 = 39739, 3$
 $39739, 3 - 330625 = 47614, 3$
 $47614, 3 \div 7206, 84 = 4, 56$
 $7206, 84 + 4, 56 = 7211, 40$
 $7211, 40^3 = 39839, 3$
 $39839, 3 - 330625 = 48214, 3$
 $48214, 3 \div 7211, 40 = 4, 60$
 $7211, 40 + 4, 60 = 7216, 00$
 $7216, 00^3 = 39939, 3$
 $39939, 3 - 330625 = 48814, 3$
 $48814, 3 \div 7216, 00 = 4, 64$
 $7216, 00 + 4, 64 = 7220, 64$
 $7220, 64^3 = 40039, 3$
 $40039, 3 - 330625 = 49414, 3$
 $49414, 3 \div 7220, 64 = 4, 68$
 $7220, 64 + 4, 68 = 7225, 32$
 $7225, 32^3 = 40139, 3$
 $40139, 3 - 330625 = 50014, 3$
 $50014, 3 \div 7225, 32 = 4, 72$
 $7225, 32 + 4, 72 = 7229, 04$
 $7229, 04^3 = 40239, 3$
 $40239, 3 - 330625 = 50614, 3$
 $50614, 3 \div 7229, 04 = 4, 76$
 $7229, 04 + 4, 76 = 7233, 80$
 $7233, 80^3 = 40339, 3$
 $40339, 3 - 330625 = 51214, 3$
 $51214, 3 \div 7233, 80 = 4, 80$
 $7233, 80 + 4, 80 = 7238, 60$
 $7238, 60^3 = 40439, 3$
 $40439, 3 - 330625 = 51814, 3$
 $51814, 3 \div 7238, 60 = 4, 84$
 $7238, 60 + 4, 84 = 7243, 44$
 $7243, 44^3 = 40539, 3$
 $40539, 3 - 330625 = 52414, 3$
 $52414, 3 \div 7243, 44 = 4, 88$
 $7243, 44 + 4, 88 = 7248, 32$
 $7248, 32^3 = 40639, 3$
 $40639, 3 - 330625 = 53014, 3$
 $53014, 3 \div 7248, 32 = 4, 92$
 $7248, 32 + 4, 92 = 7253, 24$
 $7253, 24^3 = 40739, 3$
 $40739, 3 - 330625 = 53614, 3$
 $53614, 3 \div 7253, 24 = 4, 96$
 $7253, 24 + 4, 96 = 7258, 20$
 $7258, 20^3 = 40839, 3$
 $40839, 3 - 330625 = 54214, 3$
 $54214, 3 \div 7258, 20 = 5, 00$
 $7258, 20 + 5, 00 = 7263, 20$
 $7263, 20^3 = 40939, 3$
 $40939, 3 - 330625 = 54814, 3$
 $54814, 3 \div 7263, 20 = 5, 04$
 $7263, 20 + 5, 04 = 7268, 24$
 $7268, 24^3 = 41039, 3$
 $41039, 3 - 330625 = 55414, 3$
 $55414, 3 \div 7268, 24 = 5, 08$
 $7268, 24 + 5, 08 = 7273, 32$
 $7273, 32^3 = 41139, 3$
 $41139, 3 - 330625 = 56014, 3$
 $56014, 3 \div 7273, 32 = 5, 12$
 $7273, 32 + 5, 12 = 7278, 44$
 $7278, 44^3 = 41239, 3$
 $41239, 3 - 330625 = 56614, 3$
 $56614, 3 \div 7278, 44 = 5, 16$
 $7278, 44 + 5, 16 = 7283, 60$
 $7283, 60^3 = 41339, 3$
 $41339, 3 - 330625 = 57214, 3$
 $57214, 3 \div 7283, 60 = 5, 20$
 $7283, 60 + 5, 20 = 7288, 80$
 $7288, 80^3 = 41439, 3$
 $41439, 3 - 330625 = 57814, 3$
 $57814, 3 \div 7288, 80 = 5, 24$
 $7288, 80 + 5, 24 = 7294, 04$
 $7294, 04^3 = 41539, 3$
 $41539, 3 - 330625 = 58414, 3$
 $58414, 3 \div 7294, 04 = 5, 28$
 $7294, 04 + 5, 28 = 7300, 32$
 $7300, 32^3 = 41639, 3$
 $41639, 3 - 330625 = 59014, 3$
 $59014, 3 \div 7300, 32 = 5, 32$
 $7300, 32 + 5, 32 = 7306, 64$
 $7306, 64^3 = 41739, 3$
 $41739, 3 - 330625 = 59614, 3$
 $59614, 3 \div 7306, 64 = 5, 36$
 $7306, 64 + 5, 36 = 7312, 00$
 $7312, 00^3 = 41839, 3$
 $41839, 3 - 330625 = 60214, 3$
 $60214, 3 \div 7312, 00 = 5, 40$
 $7312, 00 + 5, 40 = 7317, 40$
 $7317, 40^3 = 41939, 3$
 $41939, 3 - 330625 = 60814, 3$
 $60814, 3 \div 7317, 40 = 5, 44$
 $7317, 40 + 5, 44 = 7322, 84$
 $7322, 84^3 = 42039, 3$
 $42039, 3 - 330625 = 61414, 3$
 $61414, 3 \div 7322, 84 = 5, 48$
 $7322, 84 + 5, 48 = 7328, 32$
 $7328, 32^3 = 42139, 3$
 $42139, 3 - 330625 = 62014, 3$
 $62014, 3 \div 7328, 32 = 5, 52$
 $7328, 32 + 5, 52 = 7333, 84$
 $7333, 84^3 = 42239, 3$
 $42239, 3 - 330625 = 62614, 3$
 $62614, 3 \div 7333, 84 = 5, 56$
 $7333, 84 + 5, 56 = 7339, 40$
 $7339, 40^3 = 42339, 3$
 $42339, 3 - 330625 = 63214, 3$
 $63214, 3 \div 7339, 40 = 5, 60$

$$69, I = \frac{1322500}{329939,3}$$

$$\begin{array}{r} 69, 1 \times 12 = 829, 2) 992560, 7 (1197, 010009647852 \\ \cdot \cdot \quad 8292 \cdot \cdot \cdot \end{array}$$

16336
8292

80440
74628

58127
58044

8300
8292

80000
74628

53720
49752

39680
33168

65120
58044

70760
66336

4324
4146

178
165

13

3.) - 1197,010009647852(34,597832
3 9 34,55 = $\frac{1}{6}$

64	297
4	256

685	4101
5	3425

6909 67600
9 62181

69187 541909
7 484309

691948	5760064
8	5535584

6919563 22448078
3 20758689

69195662 168938952
138391324

30547628

Two examples being sufficient to illustrate the rule, I shall proceed to the sursolid, or fifth power. The investigation is as follows :

Let a = the resolvend ; r = the first figure in the root, and e = the remaining figures. Then $r + e$ = true root, and $r^5 + 5re + 10r^3e^2 + 10r^2e^3 + 5re^4 + e^5 = a$; and by dropping all the terms that contain a higher power of e than e^2 , and by

by making the remainder equal to a , there will be $r^5 + 5re + 10r^3e^2 = a$, and then $5re + 10r^3e^2 = a - r^5$; and by division $e^2 + \frac{1}{2}re = \frac{a-r^5}{10r^3}$; and by completing the square we shall have $e^2 + \frac{1}{2}re + \frac{r^2}{16} = \frac{a-r^5}{10r^3} + \frac{r^2}{16} = \frac{16a-6r^5}{160r^3} = \frac{8a-3r^5}{80r^3}$ *; and by extracting the square root, $e + \frac{r}{4} = \sqrt{\frac{8a-3r^5}{80r^3}}$; and by subtraction $e = -\frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}}$; and by adding r on both sides; $r + e = r - \frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}} = \frac{3}{4}r + \sqrt{\frac{8a-3r^5}{80r^3}}$. Whence this rule:

Take the nearest root to the first period of the resolvend, more or less than just, and annex as many cyphers, as there are remaining periods in the resolvend, and call it the assumed root. Multiply the resolvend by 8, and from the product take 3 times the fifth power of the assumed root; divide the remainder by 80 times the third power of the assumed root, and extract the square root of the quotient; to which add three fourths of the assumed root, and it will give the sursolid root corrected:—It may be repeated, and carried to what exactness you would have it; still taking the last root from the assumed root.

Let us take an example from *Ward*: Extract the sursolid root from 12309502009375. Here the nearest sursolid root to 1230 is 4, and the assumed root 400, less than just.

X

12309502009375

* The co-efficients are divided by their greatest common measure. *Euc. b. 7. p. 3.*

12309502009375 (400 = assumed root and making the
 $\times 8$
 98476016075000
 $400 \times 3 = 1200$ 30720000000000
 $400 \times 80 = 51200000000$ 67756016075000 (13233 (115
 $512 \dots$ 1 300 $415 = \text{root.}$
 1655 1 32
 1536 21 21
 1196 1 1133
 1024 1125
 1720 225 8
 1536
 1841
 1536
 305

One case being sufficient to exemplify the rule, I shall not trouble you with a second. The next is the second surfold, or seventh power : And let the same letters stand for the same things, as in the preceding powers ; and then we shall have $r^7 + 7r^6e + 21r^5e^2 + 35r^4e^3 + 35r^3e^4 + 21r^2e^5 + 7re^6 + e^7 = a$; and by neglecting all the terms that contain a greater power of e than e^2 , and making the remainder equal to a , there will arise $r^7 + 7r^6e + 21r^5e^2 = a$; and $7r^6e + 21r^5e^2 = a - r^7$; and by division $e^2 + \frac{1}{3}re = \frac{a - r^7}{21r^5}$; and by compleating the square, $e^2 + \frac{1}{3}re + \frac{r^2}{36} = \frac{a - r^7}{21r^5} + \frac{r^2}{36} = \frac{12a - 5r^7}{252r^5}$: * By extracting the square root of both sides of the equation, there will arise $e + \frac{1}{6}r = \sqrt{\frac{12a - 5r^7}{252r^5}}$; and $e = -\frac{1}{6}r + \sqrt{\frac{12a - 5r^7}{252r^5}}$. And furthermore, if r be added to both sides of the equation, there will be had, $r + e = r - \frac{1}{6}r + \sqrt{\frac{12a - 5r^7}{252r^5}} = \frac{5}{6}r + \sqrt{\frac{12a - 5r^7}{252r^5}}$. Whence this rule :

Take

* See note, p. 166.

Take the nearest second sursolid root to the first period of the resolvend, and place as many cyphers at it's right hand as there are remaining periods in the resolvend, and call it the assumed root. Multiply the resolvend by 12, and take 5 times the seventh power of the assumed root from the product, and divide the remainder by 252 times the fifth power of the assumed root; extract the square root of the quotient, and add the root to $\frac{5}{6}$ of the assumed root, and it will give the second sursolid root corrected; which may be repeated and carried to the desired accuracy,—remembering to take, in each operation, the last root for the assumed root. We will take *Ward's* example, viz. Extract the second sursolid root from 382986553955078125. Here the nearest root to 3829, is 3, and 300 is the assumed root, less than just.

$$\begin{array}{r}
 382986553955078125(300 \\
 \times 12 \\
 \hline
 4595838647460937500 \\
 300 \times 5 = - 103500000000000000 \\
 \hline
 300 \times 252 = 61236 | 0000000000) 3502338647460937500(5719 \\
 306180 \dots \\
 \hline
 440538 \\
 428652 \\
 \hline
 118866 \\
 61236 \\
 \hline
 576304 \\
 541124 \\
 \hline
 35180
 \end{array}$$

$$\begin{array}{r}
 7 \quad) \quad 5719 \quad (\quad 75 \\
 7 \quad \quad 49 \quad \quad 250 = \frac{5}{6} \text{ of the assumed root.} \\
 \hline
 145 \quad \quad 819 \quad \quad 325 = \text{root, agreeable to } Ward. \\
 \quad \quad 725 \\
 \hline
 \quad \quad 94
 \end{array}$$

X 2

SCHOLIUM.

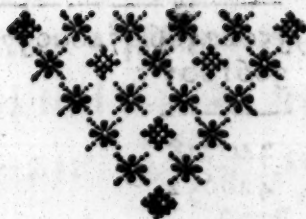
SCHOLIUM.

It may be observed, that in the foregoing examples, I have carried the work out at large : This I did in order to avoid any seeming embarrassments. Whatever contractions are made use of by *Ward*, or others, may be adopted, with equal propriety, in these methods ; and I have not met with an instance, in which these rules do not approach the root with equal celerity, as those of the forementioned author.

I am, &c.

BENJAMIN WEST.

To Mr. Caleb Gannett.



MATHEMATICAL PAPERS.

XVI. *A new and concise Method of computing Interest at Six per Cent. per Annum.* By PHILOMATH.

LET the interest of £.745 be required for 16 months at 6 per cent. per annum.

Operation at large.—According to the double Rule of Three, or (as it is sometimes called) the Rule of Five, the question will be stated thus :

If £.100 in 12 months gain £.6, what will £.745 gain in 16 months ?

For solution.—Of these five terms so ranged,

$$\begin{array}{ccccc} \text{£.} & \text{m.} & \text{£.} & \text{£.} & \text{m.} \\ 100 & : 12 & : 6 & : 745 & : 16, \end{array}$$

the three last are to be multiplied together, for a dividend ; and the two first for a division : And the quotient will be the answer to the question. Thus,

	745
	16

	4470
	745

	11920
	6

	71520 (£.59
	6000

	11520
	10800

	Remain. 720
	20

	14400 (126
	1200

	2400
	2400

	0

Answer, £.59 12 0

If

If the dividend and divisor, in the foregoing operation, be lessened in the same proportion, or, like parts, be taken instead of their wholes, as, if one sixth part of the former dividend be divided by one sixth part of the former divisor, the quotient and answer will be the same as before. But the product of the two last terms in the stating (omitting the multiplication by the third term 6) is equal to one sixth of said dividend:— Therefore, if the product of said two last terms be divided by 200, equal to one sixth of the former divisor, the quotient and answer will be as before. Thus,

$$\begin{array}{r}
 745 \\
 16 \overline{) 11920} \\
 \underline{1120} \\
 720 \\
 \underline{745} \\
 200 \overline{) 11920} \quad (\text{£.59} \\
 \underline{1000} \\
 1920 \\
 \underline{1800} \\
 \text{Remain. } 120 \\
 \underline{20} \\
 2400 \quad (\text{12s.} \\
 \underline{200} \\
 400 \\
 \underline{400}
 \end{array}$$

If instead of the dividend 11920, in the last operation, being divided by 200, it be divided by one of the two numbers, *e. g.* 10 and 20, the rectangle whereof is equal to 200, the divisor there, and the quotient thence arising be divided by the other of said two numbers, the last quotient and answer will be the same as before. Thus,

$$\begin{array}{r}
 10 \overline{) 11920} \quad (1192 \\
 \underline{10 \dots} \\
 19 \\
 10 \overline{) 1192} \quad (\text{£} .59 \\
 \underline{100 \dots} \\
 92 \\
 90 \quad \underline{192} \\
 20 \quad \underline{180} \\
 20 \quad \underline{12s.}
 \end{array}$$

Note here.—The first quotient is shillings, it taking 20 of them in the second division to make a pound; and the remainder, after the first division, (if any) expresses tenths of a shillings.

Again.—Instead of the former dividend, 11920, being divided by 200, if one half said dividend, or, half the product of the two last terms of the state of the question, (which is equal to the product of either of the said two last terms multiplied into half the other) be divided by half the said divisor 200, = 100, there will be the same quotient and answer as before. Thus,

$$\begin{array}{r}
 200 \quad 11920 \\
 \underline{100} \quad) \quad 5960 \quad (\text{£} .59 \\
 \underline{500} \\
 960 \\
 900 \\
 \underline{60} \\
 \text{Remain.} \quad 20 \\
 \underline{1200} \quad (12s. \\
 100 \\
 \underline{200} \\
 200
 \end{array}$$

From the premises result the following rules for computing interest at 6 per cent. per annum, in a new concise method, made use

If the dividend and divisor, in the foregoing operation, be lessened in the same proportion, or, like parts, be taken instead of their wholes, as, if one sixth part of the former dividend be divided by one sixth part of the former divisor, the quotient and answer will be the same as before. But the product of the two last terms in the stating (omitting the multiplication by the third term 6) is equal to one sixth of said dividend:— Therefore, if the product of said two last terms be divided by 200, equal to one sixth of the former divisor, the quotient and answer will be as before. Thus,

$$\begin{array}{r}
 745 \\
 16 \\
 \hline
 4470 \\
 745 \\
 \hline
 200 \overline{) 11920} \text{ (£.59} \\
 \underline{1000} \\
 1920 \\
 \underline{1800} \\
 \text{Remain. } 120 \\
 \underline{20} \\
 2400 \text{ (12s.} \\
 \underline{200} \\
 400 \\
 \underline{400} \\
 0
 \end{array}$$

If instead of the dividend 11920, in the last operation, being divided by 200, it be divided by one of the two numbers, *e. g.* 10 and 20, the rectangle whereof is equal to 200, the divisor there, and the quotient thence arising be divided by the other of said two numbers, the last quotient and answer will be the same as before. Thus,

$$\begin{array}{r}
 10 \overline{) 11920} \quad (1192 \\
 \underline{10 \dots} \\
 19 \\
 10 \overline{) 1192} \quad (\text{£} .59 \\
 \underline{100 \dots} \\
 92 \\
 90 \\
 \underline{20} \\
 20 \\
 \underline{20}
 \end{array}$$

Note here.—The first quotient is shillings, it taking 20 of them in the second division to make a pound; and the remainder, after the first division, (if any) expresses tenths of a shillings.

Again.—Instead of the former dividend, 11920, being divided by 200, if one half said dividend, or, half the product of the two last terms of the state of the question, (which is equal to the product of either of the said two last terms multiplied into half the other) be divided by half the said divisor 200, = 100, there will be the same quotient and answer as before. Thus,

$$\begin{array}{r}
 200 \quad 11920 \\
 \underline{100} \quad) \quad 5960 \quad (\text{£} .59 \\
 \underline{500} \\
 960 \\
 900 \\
 \underline{\text{Remain.} \quad 60} \\
 20 \\
 \underline{1200} \quad (12s. \\
 1000 \\
 \underline{200} \\
 200
 \end{array}$$

From the premises result the following rules for computing interest at 6 per cent. per annum, in a new concise method, made

use

use of by many gentlemen, but which is not commonly known.

1. If any sum of money be multiplied by the number of months and parts of a month it is at interest, at the rate of 6 per cent. per annum, and the right-hand figure of the pounds in the product be separated by a comma from the others, (if any be) those other figures will be the shillings which the interest doth come to for the time given, and the right-hand figure, separated as aforesaid, will be the decimal, that is, the tenth part of a shilling.

Example. What is the interest of £.745, for 16 months, at 6 per cent. per annum?

Operation.

$$\begin{array}{r}
 \text{£.}745 \\
 \times 16 \\
 \hline
 4470 \\
 745 \\
 \hline
 20\text{s. } 119, 2, 0 \\
 \hline
 \text{Ans. } 59, 12, 0
 \end{array}$$

2. If any sum of money be multiplied by one half of the time in months and parts of a month it is at interest, at 6 per cent. per annum, and the two right-hand figures of the pounds in the product be separated with a comma from the others, (if there be any) those other figures, if any there be, will be the pounds that the interest doth come to for the time given; and the right-hand figure, so separated, will be the decimal parts of a pound.

Example. What is the interest of £.745, for 16 months, at 6 per cent. per annum?

Operation.

Operation.

$$\begin{array}{r}
 \text{£.}745 \\
 \phantom{\text{£.}}8 \\
 \hline
 59,60 \\
 20 \\
 \hline
 12,00 \\
 \hline
 \text{Ans. } \text{£.}59\ 12
 \end{array}$$

If under either of these rules, in the product, there be no figures in the place of pounds, supply them by one or two cyphers. If under the second rule, there be but one figure in the place of pounds, supply by prefixing one or two cyphers.*

The multiplication of pounds, shillings, pence, &c. by months and such number of days as are not an exact half, third part, &c. of a month, may indeed sometimes prove burthensome to the mind.

But by the help of the two subsequent tables of decimals, one of the parts of a pound, and the other of the parts of a month, the interest of any sum of money, consisting of divers denominations of pounds, shillings, pence, and even farthings, for any given number of months and days, may, upon the principles on which the second rule aforegoing is founded, by an easy process and with sufficient accuracy, be computed.

Y

A

* In both these rules, the sum at interest is supposed to be given in pounds, &c. But if the sum at interest be given in dollars, the interest thereon may be computed by the second rule; only observing, that the figures in the product, (of the sum by half the time) on the left hand of the comma, will be dollars, and those on the right hand will be the decimal parts of a dollar.

A Table of Decimal Parts of a Pound, or twenty Shillings.

f.	d.	q.	f.	d.	f.	d.	f.	d.	l.	f.	d.					
0	0	1	0010	3	11	1959	8	0	4000	12	1	6042	0	16	2	8084
	0	2	0021	4	0	2000	8	1	4042	12	2	6084		16	3	8125
	0	3	0031	4	1	2042	8	2	4084	12	3	6125		16	4	8167
	1	0	0042	4	2	2084	8	3	4125	12	4	6167		16	5	8209
	2	0	0084	4	3	2125	8	4	4167	12	5	6209		16	6	8250
	3	0	0125	4	4	2167	8	5	4209	12	6	6250		16	7	8292
	4	0	0167	4	5	2209	8	6	4250	12	7	6292		16	8	8334
	5	0	0209	4	6	2250	8	7	4292	12	8	6334		16	9	8375
	6	0	0250	4	7	2292	8	8	4334	12	9	6375		16	10	8417
	7	0	0292	4	8	2334	8	9	4375	12	10	6417		16	11	8459
	8	0	0334	4	9	2375	8	10	4417	12	11	6459		17	0	8500
	9	0	0375	4	10	2417	8	11	4459	13	0	6500		17	1	8542
	10	0	0417	4	11	2459	9	0	4500	13	1	6542		17	2	8584
	11	0	0459	5	0	2500	9	1	4542	13	2	6584		17	3	8625
1	0	0	0500	5	1	2542	9	2	4584	13	3	6625		17	4	8667
1	1	0	0542	5	2	2584	9	3	4625	13	4	6667		17	5	8709
1	2	0	0584	5	3	2625	9	4	4667	13	5	6709		17	6	8750
1	3	0	0625	5	4	2667	9	5	4709	13	6	6750		17	7	8792
1	4	0	0667	5	5	2709	9	6	4750	13	7	6792		17	8	8834
1	5	0	0709	5	6	2750	9	7	4792	13	8	6834		17	9	8875
1	6	0	0750	5	7	2792	9	8	4834	13	9	6875		17	10	8917
1	7	0	0792	5	8	2834	9	9	4875	13	10	6917		17	11	8959
1	8	0	0834	5	9	2875	9	10	4917	13	11	6959		18	0	9000
1	9	0	0875	5	10	2917	9	11	4959	14	0	7000		18	1	9042
1	10	0	0917	5	11	2959	10	0	5000	14	1	7042		18	2	9084
1	11	0	0959	6	0	3000	10	1	5042	14	2	7084		18	3	9125
2	0	0	1000	6	1	3042	10	2	5084	14	3	7125		18	4	9167
2	1	0	1042	6	2	3084	10	3	5125	14	4	7167		18	5	9209
2	2	0	1084	6	3	3125	10	4	5167	14	5	7209		18	6	9250
2	3	0	1125	6	4	3167	10	5	5209	14	6	7250		18	7	9292
2	4	0	1167	6	5	3209	10	6	5250	14	7	7292		18	8	9334
2	5	0	1209	6	6	3250	10	7	5292	14	8	7334		18	9	9375
2	6	0	1250	6	7	3292	10	8	5334	14	9	7375		18	10	9417
2	7	0	1292	6	8	3334	10	9	5375	14	10	7417		18	11	9449
2	8	0	1334	6	9	3375	10	10	5417	14	11	7459		19	0	9500
2	9	0	1375	6	10	3417	10	11	5459	15	0	7500		19	1	9542
2	10	0	1417	6	11	3459	11	0	5500	15	1	7542		19	2	9584
2	11	0	1459	7	0	3500	11	1	5542	15	2	7584		19	3	9625
3	0	0	1500	7	1	3542	11	2	5584	15	3	7625		19	4	9667
3	1	0	1542	7	2	3584	11	3	5625	15	4	7667		19	5	9709
3	2	0	1584	7	3	3625	11	4	5667	15	5	7709		19	6	9750
3	3	0	1625	7	4	3667	11	5	5709	15	6	7750		19	7	9792
3	4	0	1667	7	5	3709	11	6	5750	15	7	7792		19	8	9834
3	5	0	1709	7	6	3750	11	7	5792	15	8	7834		19	9	9875
3	6	0	1750	7	7	3792	11	8	5834	15	9	7875		19	10	9917
3	7	0	1792	7	8	3834	11	9	5875	15	10	7917		19	11	9959
3	8	0	1834	7	9	3875	11	10	5917	15	11	7959	1	0	0	10000
3	9	0	1875	7	10	3917	11	11	5959	16	0	8000				
3	10	0	1917	7	11	3959	12	0	6000	16	1	8042				

A Table of Decimal Parts of a Month.

Days.		D.		D.		D.		M.D.	
1	0333	7	2333	13	4333	19	6333	25	8333
2	0667	8	2667	14	4667	20	6667	26	8667
3	1000	9	3000	15	5000	21	7000	27	9000
4	1333	10	3333	16	5333	22	7333	28	9333
5	1667	11	3667	17	5667	23	7667	29	9667
6	2000	12	4000	18	6000	24	8000	1 0	1,0000

When interest at the rate of 6 per cent. per annum, is to be computed on any given sum of money and for any given time, and the money or time, or both, be of divers denominations, set down the money at interest in pounds and decimal parts of a pound, and the time in months and decimal parts of a month, (the decimals being taken from the tables respectively) and multiply the whole of one of them by half of the other, and count off two more of the right-hand figures of the product than there are places of decimals in the multiplicand and multiplier together, and there place a comma, to separate them from the other figures of the product, if any be ; but if there be not so many figures in the product, supply them by prefixing cyphers ; and then the figures (if there be any) on the left hand of the comma, will be the pounds that the interest comes to for the given time ; and the figures on the right hand of the comma will be decimal parts of a pound,—three or four of which, next the comma, may be sufficient in common cases to retain, and the rest may be expunged.

Example. Let the interest of £.745 15s. 6d. for 1 year 7 months and 11 days, at 6 per cent. per annum, be computed.

Y 2 Money.

Money.	M. Time.
£.745, 775	2)19, 3667
9, 6833	<u>9, 6833</u>
<u>2237325</u>	
2237325	
5966200	
4474650	
<u>6711975</u>	
72,2156	
20	
<u>4,3120</u>	
12	
<u>3,6440</u>	
4	
<u>2,5760</u>	
Ans. £.72. 4s. 3d. 2q.	

This method is adapted to reckoning interest at the rate of 6 per cent.—But from the interest at 6 per cent. the interest at any other given rate may be obtained, as follows :

One *sixth* part of the interest at 6 per cent. is the interest at 1 per cent.—One *third* is the interest at 2 per cent.—One *half* is the interest at 3 per cent. If from the interest at 6 per cent. there be subtracted one *third* of it, the remainder will be the interest at 4 per cent.—If one *sixth* be subtracted, the remainder will be the interest at 5 per cent.

Again.—If to the interest at 6 per cent. there be added one *sixth* part thereof, the sum will be the interest at 7 per cent.—If there be added one *third*, the sum will be the interest at 8 per cent.—If there be added *half*, the sum will be the interest at 9 per cent.—If two *thirds*, the sum will be the interest at 10 per cent.—If one *half* and one *third*, the sum will be the interest at 11 per cent.—The double of the interest at 6 per cent.

cent. is the interest at 12 per cent.—If to that double there be added one sixth of the interest at 6 per cent. the sum will be the interest at 13 per cent. &c.

And this division, addition or subtraction may be made immediately after the first operation of multiplying the money at interest by half the time, or *à contra*, and before the separating the figures into pounds and decimals.

Example. Let there be computed the interest of £.480, for 7 months and 15 days, at 5 per cent. per annum.

£.480,	M.
3,75	7, 50
—	—
2400	3, 75
3360	
1440	
—	
180000 at 6 per cent.	
30000 $\frac{1}{6}$ deduct.	
—	
15,0000 at 5 per cent.	
Ans. £.15.	

Example. Let the interest of £.345 15s. for 9 months and 6 days, be computed, at the rate of 7 per cent. per annum.

£.345,75	9,20
4, 60	—
—	4,60 half the time.
2074500	
138300	
—	
15904500 at 6 per cent.	
2650750 $\frac{1}{6}$ add.	
—	
18,565250 at 7 per cent.	
20	
—	
11,305000	
12	
—	
3,660000	
4	
—	
2,640000	
Ans. £.18 11s. 3d. 2q.	

Let

Let it be observed here,—in this process as well as others, where there are decimals of a pound to be valued, there is no need of the several multiplications by 20, 12 and 4 for that purpose : But the preceding table of decimal parts of a pound being calculated to four places, if we repair to that with so many of the decimals (next the comma) to be valued, we shall there find their value, by inspection.

May 15, 1781.



XVII. *Several Ways of determining what Sum is to be insured on an Adventure, that the whole Interest may be covered.*
By MERCATOR.

I. **T**HE first and most common way is, to cast the premium of insurance at the stipulated rate, on the adventure,—on that premium,—on the premium of the first premium, and so on until the premium be so small as not to be worth noticing ; then to collect the adventure and these several premiums (first and secondary) into one sum, which will be the sum to be insured.

Example. Adventure, £.315 ;—rate of insurance, 30 per cent.

First premium.

$$\begin{array}{r} \text{£.}315 \\ 30 \\ \hline 94,50 \\ 20 \\ \hline 10,00 \end{array}$$

$$\begin{array}{r} \text{£.}94.10.0 \\ 10 \\ \hline 945.0.0 \\ 3 \\ \hline 28,35.0.0 \\ 20 \\ \hline 7,00 \end{array}$$

Second premium.

$$\begin{array}{r} \text{£.}28.7.0 \\ 10 \\ \hline 283.10.0 \\ 3 \\ \hline 8,50.10.0 \\ 20 \\ \hline 10,10 \\ 12 \\ \hline 1,20 \\ 4 \\ \hline ,80 \end{array}$$

Third premium.

$$\begin{array}{r} \text{£.}8.10.1\frac{1}{4} \\ 3 \\ \hline 25.10.3\frac{3}{10} \\ 10 \\ \hline 2,55.3.1\frac{2}{10} \\ 20 \\ \hline 11,03 \\ 12 \\ \hline ,37 \\ 4 \\ \hline 1,50 \end{array}$$

Fourth

Fourth premium.

$$\begin{array}{r} \text{£. 2. 11. 0. 2} \\ 10 \end{array}$$

$$\begin{array}{r} 25. 10. 5. 0 \\ 3 \end{array}$$

$$\begin{array}{r} ,76. 11. 3. 0 \\ 20 \end{array}$$

$$\begin{array}{r} 15,31 \\ 12 \end{array}$$

$$\begin{array}{r} 3,75 \\ 4 \end{array}$$

$$\begin{array}{r} 3,90 \end{array}$$

Fifth premium.

$$\begin{array}{r} \text{£. 0. 15. 3. 3} \\ 10 \end{array}$$

$$\begin{array}{r} 7. 13. 1. 2 \\ 3 \end{array}$$

$$\begin{array}{r} ,22. 19. 4. 2 \\ 20 \end{array}$$

$$\begin{array}{r} 4,59 \\ 12 \end{array}$$

$$\begin{array}{r} 7,12 \\ 4 \end{array}$$

$$\begin{array}{r} ,50 \end{array}$$

Collection.

Adventure, £. 315. 0. 0. 0

1st. premium, 94. 10. 0. 0

2d. 28. 7. 0. 0

3d. 8. 10. 1. 1

4th. 2. 11. 0. 2

5th. 15. 3. 3

6th. 4. 7. 1

7th. 1. 4. 2

8th. 0. 5. 0

9th. 0. 1. 2

10th. 0. 2

$$\begin{array}{r} 450. 0. 0. 1 \end{array}$$

Sixth premium.

$$\begin{array}{r} \text{£. 0. 4. 7. 1} \\ 3 \end{array}$$

$$\begin{array}{r} 0. 13. 9. 3 \\ 10 \end{array}$$

$$\begin{array}{r} ,06. 18. 1. 2 \\ 20 \end{array}$$

$$\begin{array}{r} 1,38 \\ 12 \end{array}$$

$$\begin{array}{r} 4,57 \\ 4 \end{array}$$

$$\begin{array}{r} 2,30 \end{array}$$

Seventh premium.

$$\begin{array}{r} \text{£. 0. 1. 4. 2} \\ 30 \end{array}$$

$$\begin{array}{r} ,1. 3. 0 \\ 10 \end{array}$$

$$\begin{array}{r} 1. 10 \end{array}$$

$$\begin{array}{r} ,02. 1. 3. 0 \\ 20 \end{array}$$

$$\begin{array}{r} ,041 \\ 12 \end{array}$$

$$\begin{array}{r} 4,95 \end{array}$$

Eighth premium.

$$\begin{array}{r} \text{£. 0. 0. 5. 0} \\ 30 \end{array}$$

$$\begin{array}{r} 0. 12. 6. 0 \\ 12 \end{array}$$

$$\begin{array}{r} ,50 \\ 4 \end{array}$$

$$\begin{array}{r} 2,00 \end{array}$$

Ninth premium.

$$\begin{array}{r} \text{£. 0. 0. 1. 2} \\ 30 \end{array}$$

$$\begin{array}{r} 1. 3. 0 \\ 2. 6. \end{array}$$

$$\begin{array}{r} 3. 9. 0 \\ 12 \end{array}$$

$$\begin{array}{r} ,45 \\ 4 \end{array}$$

$$\begin{array}{r} 1,80 \end{array}$$

Tenth premium.

2 farthings.

And

And observe:—The greater the rate of insurance, the more operations are requisite; because the less of the adventure will be covered by the insurance of each preceding premium.

2. Another way.—Cast the premium of insurance on the adventure, (as before) which, subtract from the adventure;—then, by the Rule of Three, it will be—as that remainder : the adventure :: the adventure : the sum to be insured.

Example. Adventure, £.315.—Rate of insurance, 30 per cent.

£.315	£.315. 0. 0	As £.220. 10s. :	£.315 ::	£.315 :
30	94. 10. 0	20	20	
94,50	Remain. 220. 10. 0	4410	6300	
20			315	
10,00			31500	
			6300	
			18900	
			4410) 1984500(450	
			17640	
			22050	
			22050	
			000000	

The last operation here is best done, in many cases, by decimal arithmetick : Thus,

As 220,5 :	315 ::	315
315		
99225		
220,5)	99225,0 (	450
	8820	
	11025	
	11025	
	000000	

Z

3. Another

3. Another and very expeditious way is as follows :
 Multiply the adventure by 100, and divide the product by
 100 less the rate of insurance, (or, the difference between 100
 and the rate of insurance) and the quotient will shew the sum
 to be insured.

Example. Adventure, £315. Rate of insurance, 30 per
 cent.

Adventure	Rate of Insurance	Sum to be Insured
£315	30	£450
100	70	31500
30		2800
		350
		0000



The last operation here is done in many cases by de-
 cimal arithmetic : Thus,

315	100	450
315	70	31500
315	30	2800
315		350
315		0000

Another

PART II.
PHYSICAL PAPERS.

I. *Observations upon an Hypothesis for solving the Phenomena of Light: with incidental Observations, tending to shew the Heterogeneousness of Light, and of the electric Fluid, by their Intermixture, or Union, with each other.*

By JAMES BOWDOIN, Esquire,
President of the American Academy of Arts and Sciences.

IN reviewing some letters I had written to a philosophical friend, Dr. Franklin, there occurred on the subject of one of them some observations, which appeared to me new. They are principally contained in the two last of three memoirs, which I shall lay before the Academy to whose judgment it will be submitted, whether they have any thing beside their novelty to recommend them.

As they were occasioned by considering Dr. Franklin's queries concerning light, the strictures on those queries, as being introductory to the observations, will make a part of these memoirs.

The first memoir will accordingly contain a few strictures, or cursory remarks, on his hypothesis for solving the phenomena of light: with incidental observations concerning the heterogeneousness of light, and the electric fluid.

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It is offered in full confidence, that our celebrated country-man, whose happy genius has contributed so largely to the advancement of philosophic knowledge, will be pleased with any attempt for that purpose, whether successful or not, even though it should be upon principles, that may not perfectly harmonize with some of his own.

The Doctor, dissatisfied with the received doctrine concerning light, offers several objections to it in the form of queries; and in the same form proposes an hypothesis of his own: both of which will be considered.

With respect to the hypothesis, it is asked—* “May not all the phenomena of light be more conveniently solved, by supposing universal space filled with a subtle elastic fluid, which, when at rest, is not visible, but whose vibrations affect that fine sense in the eye, as those of air do the grosser organs of the ear? We do not, in the case of sound, imagine that any sonorous particles are thrown off from a bell, for instance, and fly in straight lines to the ear: why must we believe that luminous particles leave the sun, and proceed to the eye? Some diamonds, if rubbed, shine in the dark, without losing any part of their matter. I can make an electrical spark as big as the flame of a candle, much brighter, and therefore visible further; yet this is without fuel: and I am persuaded no part of the electric fluid flies off in such case to distant places, but all goes directly, and is to be found in the place to which I destine it.—May not different degrees of the vibration of the above-mentioned universal medium, occasion the appearances of different colours? I think the electric fluid is always the same; yet

* See Letters and Papers on Philosophical Subjects. p. 265. edit. 1769.

yet I find that weaker and stronger sparks differ in apparent colour: Some white, blue, purple, red;—the strongest, white; weak ones, red."

Several objections here present themselves. Some of them arising from the hypothesis itself; and others from the comparison of light with sound.

In respect of the former, if universal space be filled with a subtle elastic fluid, (so as to exclude any vacuum) that fluid must always be at rest, and therefore by the hypothesis always invisible; and consequently there would always be universal darkness. Or if any part of the fluid could be put in motion, the whole of it must be in motion: for not one particle of it could move, without moving, in the direction of its motion, the adjoining one, and this the next; and so on, *ad infinitum*. In this case, the least motion, wherever it might commence, must produce universal motion; and consequently, universal light: between which, and universal darkness, there could be no medium.

But if the meaning of the expression be, what it was probably intended to be, that universal space, instead of being filled, doth greatly abound, with an elastic fluid, then would not every thing, which disturbed that fluid, cause a luminous appearance? Would not the inhabitants of the sea and air, in all their motions, bespangle both; and thereby exhibit the various colours according to the different degrees of vibration, which those motions might occasion in the elastic fluid?—As to ourselves, would not a radiance attend us wherever we went? What occasion should we have of candle-light, when a quick vibration of the hand, or of machines made for that purpose, would dispel the night? Or rather, might we not suppose there

there would be no night at all: for the action of the sun (if the sun should be necessary) would be communicated to us, notwithstanding the interposition of the earth. And would not the effect of that action, even at noon when most direct, be only to enlighten us, unattended with heat, so essentially necessary to enliven and invigorate the animal and vegetable world?—Would not the elastic fluid, instead of exhibiting a round luminous body, which we call the sun, be itself a continued universal blaze of light? And would not this, in the present constitution of things, obstruct vision, and totally alter the science of optics?

The objections, implied in the foregoing queries, seem deducible from the hypothesis. There are several, which appear to arise from the comparison of light with sound.

1° As sound (or a vibrating, or undulating, motion in the air, which I consider here as synonymous) is propagated from the sonorous body in all directions; and surrounds, and is propagated beyond or behind any obstacle in its way: so light, if it was a vibration, or undulation, of the elastic fluid, would surround, and be propagated behind an obstacle, like sound: but this does not agree with the fact.—2° As sound, or the vibrating motion in the air, originating in a house or any other inclosure, would, from a hole in one of the sides of it, be propagated externally, in circles, of which the hole would be the centre: so light, if it was a vibration, or occasioned by a vibration, of the elastic fluid, after passing through a hole, would be propagated in circles, of which the hole would be the centre. But this does not correspond to the fact: for light, in passing through any uniform medium, always passes in right lines.

Beside

Beside these, an objection similar to one of those, which have been advanced against the common hypothesis, and which may be seen in the proper place, may be alledged against this : for the constant vibration, with which the elastic fluid must be agitated, would communicate to small bodies, and even to large ones suspended in that fluid, a constant tremulous vibratory motion. In such a case it would be difficult to examine the texture and visible qualities of those small bodies, as one necessary mean of examination, a great deal of light, would encrease the vibration ; and thereby render the examination not only difficult but impracticable. It is apprehended, however, that no such motion, or embarrassment, in the making of such examinations, has ever been observed.

What is mentioned about the electrical spark, that it is bright, and visible at a distance, and this without fuel ; and that no part of the electrical fluid flies off, in such case, to distant places, but all goes directly, and is to be found in the place, to which it is destined, appears to favour the hypothesis ; as the implied inference seems to be, that the visibility of the electric spark arises from the vibration it produces in the universal elastic fluid. But if the foregoing queries furnish sufficient reason for doubting the existence of such a fluid, or for doubting such an effect from it, supposing its existence, will they not furnish equal reason for doubting the hypothesis ?

The visibility of the electric spark may be accounted for, upon the principles of the received doctrine concerning light, without supposing any diminution of the pure electric fluid in the spark : no part of which, it is said, flies off in the case mentioned.

It

It seems not improbable, that the electric fluid is heterogeneous as well as light.

The heterogeneity of light is inferred from its colours, which are said to vary proportionably, as the size of the particles doth vary: the variation becoming conspicuous by a prism, and by other means, which class the particles according to their respective magnitudes, or degrees of refrangibility, and reflexivity.

Beside this, another reason may be suggested, from which the heterogeneity of light may be deduced: namely, because it exhibits effects similar to some of those of electricity. For example, a globe or pane of glass warmed in the sun or before a fire, will successively attract and repel small cork balls, down, and such like bodies insulated, and properly circumstanced; and will shew other signs of electricity communicated to the glass by the sun or fire.

So, in regard to electricity, its heterogeneity may be collected from its producing effects resembling some of those of light or fire; which are here considered as equivalent terms.

Electricity and fire differ in many respects, and in some they agree; as hath been shewn in Dr. *Franklin's* letters on electricity. So far as they agree in their effects, their nature may be presumed to be alike: Or rather, from that agreement and similitude of effects, I think it may be inferred, that they are mixt with, and generally do accompany each other; and that each produces its own effect at the time of their joint operation. The effects of electricity, similar to those of fire, being produced by the fire mixt with it; and the effects of fire, resembling those of electricity, being produced by the electricity mixt with that: the compound taking its name from the predominant principle.

Thus,

Thus, fire inflames bodies, and throws its particles or light at a distance. Hence, the explosion of gun-powder, and the luminous appearance, occasioned by the electric spark : the fire mixt with it producing those effects.

Thus also, electricity attracts and repels certain small bodies alternately, under given circumstances. Hence, the alternate attraction and repulsion of glafs, and some other things, heated by fire : the electricity mixt with the communicated fire producing those effects.

In this way I would infer the heterogeneousness of light and electricity, and their mixture with each other ; and in this way account for the similitude and difference of their effects ; and for the luminous appearance or visibility of the electric spark in particular, without diminishing the pure electric fluid contained in it : all of which, in the case referred to, is said to go directly, and is to be found in the place, to which it was destined.

On the same principles the shining of diamonds in the dark when rubbed, and thereby electrified, may be accounted for, without supposing they loose any part of their matter.

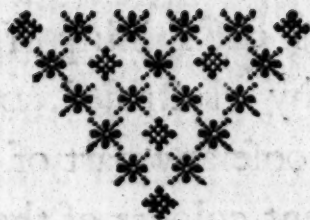
In regard to the different colours of the electric spark, which are more or less strong according to the strength of the spark, they correspond to the different colours of light or fire, which are more or less vivid according to the density or intenseness of that element. This sameness of effect shews a sameness of cause, or that the light or fire mixt with the electric spark produces those colours : whose strength or vividness being according to the bigness of the spark, or to its quantity of electric fluid, makes it probable, that in proportion to the quantity, there is more or less light or fire contained in that fluid.

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These different appearances seem to be a further instance or proof of the heterogeneity of the electric fluid; and, taken in connection with other appearances above-mentioned, shew the intermixture, and the consequent heterogeneity, of the two elements.

The next thing to be considered is, the objections to the received doctrine concerning light.—But this will be the subject of another memoir.



II. *Observations on Light, and the Waste of Matter in the Sun and fixt Stars, occasioned by the constant Efflux of Light from them : with a Conjecture, proposed by Way of Query, and suggesting a Mean, by which their several Systems might be preserved from the Disorder and final Ruin, to which they seem liable by that Waste of Matter, and by the Law of Gravitation.*

By JAMES BOWDOIN, Esquire,
President of the American Academy of Arts and Sciences.

HAVING in a preceding memoir laid before the Academy the observations, that occurred on the subject of Dr. Franklin's hypothesis relative to light, I shall now consider his objections to the received doctrine concerning it.

The objections will appear by the following paragraph taken from one of his letters on philosophical subjects.

"I must own, says the Doctor,* I am much in the dark about light. I am not satisfied with the doctrine, that supposes particles of matter called light, continually driven off from the sun's surface, with a swiftness so prodigious ! Must not the smallest particle conceivable have, with such a motion, a force exceeding that of a twenty-four pounder, discharged from a can-

A a 2 non ?

* See Letters and Papers on Philosophical Subjects. p. 264. edit. 1769.

Just as these memoirs were going to the press, an ingenious gentleman of the American Academy, favoured me with the Philosophical Transactions for 1770, (the 60th vol.) in which the Rev. Dr. Horsley, in a paper entitled, "Difficulties in the Newtonian Theory of Light, considered and removed," quotes this passage from Dr. Franklin's letters ; and very ingeniously discusses the questions contained in it.

The subject being considered in that paper, upon principles different from those adopted in this memoir, there will not be found any similitude between them.

non ? Must not the sun diminish exceedingly by such a waste of matter ? and the planets, instead of drawing nearer to him, as some have feared, recede to greater distances through the lessened attraction ? Yet these particles, with this amazing motion, will not drive before them, or remove, the least and lightest dust they meet with : and the sun, for aught we know, continues of his ancient dimensions ; and his attendants move in their ancient orbits."

The Doctor's dissatisfaction with the received doctrine, is founded on two objections implied in his queries, and which may be expressed in the following propositions.

1°. That, supposing the doctrine true, the smallest particle of light must be driven to us with prodigious force, a force exceeding that of a twenty-four pounder, discharged from a cannon. But this is contrary to fact.

2°. That the sun must be exceedingly diminished by such a waste of matter ; and the planets, in consequence of it, must recede to greater distances from him. But, for aught we know, both the sun and the planets, continue in their ancient state.

From these propositions it is implicitly inferred, that the doctrine is not well founded.

Among the observations on the second proposition, an hypothesis will be proposed, by way of query, suggesting a mean, whereby the material system, collectively taken, might be preserved from the disorder and ruin, to which they seem liable from causes hinted at in that proposition.

In regard to the objection contained in the first proposition, it adopts the idea, that light, like any other body in motion, will strike with a force proportioned to the degree of its motion ; which degree of motion, or the celerity, multiplied by the

the quantity of matter in the body, will, in the result, express its force or momentum.

If, then, we can suppose the quantity of matter in a particle of light to be, not indeed absolutely, but comparatively, o , its momentum will also be comparatively o ; and it can have, in that case, no visible effect on the smallest particle of dust to remove it.

Let us now consider what reason there is for such a supposition. In order to that, I beg leave to introduce here, a paragraph from one of my letters to Dr. Franklin, printed with his letters and papers on philosophical subjects. It runs thus,*

"The flame of a candle, it is said, may be seen four miles round. The light, diffused through this circle of eight miles diameter, was contained; before it left the candle, within a circle of half an inch diameter. If the density of light, in these circumstances, be as those circles to each other, that is, as the squares of their diameters (or, which is equivalent, if the density decreases as the square of the distance or semi-diameter increases) the candle-light, when come to the eye, will be 1027,709,337,600 times rarer than when it first quitted the half-inch circle. Now the aperture of the eye, through which the light passes, does not exceed one-tenth of an inch diameter, and the portion of the less circle, which corresponds to this small portion of the greater circle, must be proportionably, that is, 1027,709,337,600 times less than one-tenth of an inch: and yet this infinitely small point (if you will allow the expression) affords light enough to make it visible: or rather, affords light sufficient to affect the sight at that distance."

If

* Letters, &c. p. 275.

If the calculation, referred to in that paragraph, be just; and we should suppose a single particle of light, though incomparably smaller, to be in bigness equal to that point, I would ask, whether the quantity of matter in such a particle would not be small in a greater degree than its velocity, equal to that of the sun's light, would be great? If so, a particle of light in motion, agreeably to the foregoing supposition, may be here estimated 0, and its momentum not sufficient to remove the lightest dust; much less to do as much execution as a twenty-four pounder, discharged from a cannon.

It is impossible to calculate the momentum, where the requisite data cannot be had: but supposing the candle-flame equal in bulk to a sphere of half an inch diameter, and to weigh as much as an equal bulk of air, viz. about one thirtieth part of a grain; though in fact its gravity is incomputably less than that of air: then the square aforesaid will express the proportion, in which the density of the candle-light is diminished at the verge of the greater circle: and the same proportion of one thirtieth of a grain will express the weight of that light at the verge, viz. one 30,831,280,128,000th part of a grain; which we will consider as the weight of a single particle of the sun's light. If the velocity of light be at the rate of 80,000,000 miles in six minutes, then its velocity will be 222,222 miles, equal to 14,679,985,920 inches, in a second. This number of inches, divided by 30,831,280,128,000, the supposed particles in a grain, will shew the degree of motion required in a body weighing one grain to give it a momentum, equal to that of a particle of light, upon the hypothesis assumed: which motion will be 456 millionth parts of an inch in a second, equal to one inch in 2190 seconds, or thirty six minutes and an half; and is much

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slower than the hour-hand of a common clock : which, with its greater degree of motion, and much greater quantity of matter, does not give to the smallest bodies, placed in its way, any visible motion.

Precision in this calculation is not aimed at, and the nature of the subject does not admit of it : but it is apprehended, it will appear sufficiently evident from it, that light, even if its velocity were much greater than it is, and its gravity equal to that of air, to which, with great disadvantage to the argument, it has been, in that respect, compared, cannot drive before it the lightest dust, or, indeed, give it any sensible motion at all.

To the same purpose it may be further observed, that light reflected to the eye through a microscope and prism, would, it is apprehended, exhibit the same variety of colours, as light coming directly from the sun. In which case, the ray so viewed, (like the candle-ray, which has been considered as a single particle only) must be composed of a multitude of particles ; and be a proof, that the particles of light are inconceivably smaller than the calculation supposes. This degree of smallness, however, represents them to be of great magnitude, compared with their real size : for when we consider, that the sun's light is diffused through the whole solar system, and much beyond it ; and that a part of it, in that attenuated state, is reflected to us from the planets, in which reflection it undergoes, by its divergence, a further, and an extreme, attenuation : and especially when we consider the immense sphere, throughout which the light of the fixt stars is visible, particularly those of them, whose distance is so vast, that, at opposite points of the earth's orbit, they have no sensible parallax—the divisibility of light, and the proportionable tenuity of its particles, confound
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the imagination ; and render human calculation inadequate to express the precise degree of them, or the inconsiderableness of the momentum of those particles.

This inadequateness is particularly applicable to the foregoing calculation : which was purposely made on the disadvantageous principles assumed in it, to shew, that even on such principles, the momentum of light could produce no visible motion in the smallest bodies, that fall under our notice. But had the calculation been founded on the state of the sun's light reflected from one of the planets, for instance, the Georgium Sidus, lately discovered by Mr. *Herschell*, the result would have been widely different ; and we should, in that case, have had a juster idea of the momentum. The light reflected to the earth from that planet, whose mean distance from the sun is said to be 5,000,000,000 miles, is so extremely attenuated, that the momentum of a particle of it, transferred to a body, weighing a millionth part of a grain, would communicate to it so small a degree of motion, that it would require millions of ages for that body to move the diminutive part of an inch mentioned in that calculation.

If these observations be just, it is apprehended they shew, with some degree of evidence, that a particle of light, notwithstanding its prodigious velocity, cannot by its impulse remove other bodies, or displace even the finest microscopic dust ; and that the doctrine objected to, may be true, notwithstanding the first of the two objections, which have been made to it.

The second proposition, containing the other objection, is, that in case there are particles of matter, called light, continually driven off from the sun's surface, the sun must be exceedingly diminished by such a waste of matter ; and the planets,

nets, in consequence of it, must recede to greater distances from him, through the lessened attraction.

Here I beg leave to observe, that if the material system, in its present form, was not intended by its Creator to be perpetual, then the waste of the sun's matter, and the consequent disorder in the system, arising from the altered state of its gravitation, will only be a proof of that intention; and not operate against the truth of the doctrine.

That system, like every other, derived from the same original, doubtless has within itself the means of continuing in its present form, until the great and wise purposes of its Author shall be brought into effect, and compleatly answered.

With respect to the solar system, so far as its continuance depends on the sun, it seems calculated, notwithstanding the supposed waste of the sun's matter, to last for many ages: for the sun, by reason of its prodigious bulk, and the divisibility of its matter, must, from its own internal sources, furnish light to the system through a long tract of time, without being sensibly diminished. If those eccentric bodies, called comets, which have been thought intended to recruit the sun's waste of matter, do in fact answer that purpose, provision is then made for the preservation of the system, at least until those bodies shall have all successively fallen into the sun, and been expended. When that shall happen, if there be provided no further means of recruit, the system will begin to decay, and finally be reduced to a chaotic state: from which, like our earth, it may be restored in some new form, to answer the further purposes of the Creator. I mention our earth, as in the *Mosaic* account of it, its original is described in such a manner, as to give us the idea of its having been an old planet, by some means or other

reduced to a chaos ; from which it was renovated, and made suitable for the purposes, to which it has been applied.

There is nothing unreasonable, or improbable, in that idea : and if the earth was so renovated, it may be inferred from analogy, that in case the present system should go to decay, a new one, and perhaps a superior one, would arise from its ruins.

These observations are founded on the idea of the waste of the sun's matter, and its final dissolution, with that of the system depending upon it : whether gradually occasioned by that waste of matter, or more rapidly brought on by the general law of gravitation. In this view of things, the objection does not militate with the doctrine.

But perhaps it may be thought more philosophical, and that it would better comport with our ideas of the wisdom of the Creator to suppose, that when he created the system, he intended it should be a permanent one ; and at the same time furnished it with the means of its own preservation. In which case, may it not be further supposed, particularly with regard to the efflux of light from the sun, by which its matter is conceived to be wasted, that he provided means, whereby the effluent particles, after answering the purpose of their efflux, should be returned to the sun, to answer again, in a constant succession, the same purpose.

I do not know, whether the hypothesis, suggested in the following queries, and relative to that subject, be admissible, or not. It is however offered for consideration.

It was primarily and specially intended to suggest a mean for preventing the ruin, to which the material system seems liable from the general principle of gravitation : but the same mean may possibly be applied to restore to the sun, in a regular succession

cession, its effluent light; and thereby obviate the evil effects, that might otherwise follow from the efflux.

Is it not conceivable, that round the solar system, and the several systems, which compose the visible heavens, there might have been formed a hollow sphere, or orb, made of matter *sui generis*, or of matter like that of the planets, and surrounding the whole: having its inner or concave surface at a proper distance therefrom; beyond which surface light could not pass, and between which, and the particles of light, there should be a mutual repulsion? And might not the sun, or source of light, of each system, have been so placed, in respect of each other, and the concave surface of the surrounding orb, that there should be, by direct and repeatedly indirect reflections, an interchange of rays between them, in such a manner, as that to each there should be restored the quantity it had emitted; and thereby the waste of its matter be prevented: and this at the same time it dispensed its light to its particular system?

This use of such an orb is here meant to be considered as a secondary or incidental one; to which it might be applied: but the principal or primary use of it, as a counter-balance to the gravitating principle of the systems contained within it, will be seen in its proper place.

There is a remarkable phenomenon in the solar system, to which the ideal one, just mentioned, bears some resemblance, and by which it was suggested: I mean the ring or arch, which surrounds the planet Saturn. We are told by astronomers, that its width, and also its distance from Saturn, is about 25,000 miles;—forming around that planet a beautiful arch, which may be designed, among other purposes, to increase its light and heat, by reflecting upon it, like a concave mirror, the sun's

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rays : of which, by reason of its great distance from the sun, it would not otherwise have had a sufficient quantity.

If Saturn were a luminous body *per se*, and the arch, (made of suitable matter, and properly constructed, for the purpose) entirely environed it, the whole quantity of light emitted from it, would be reflected back ; and no waste of its matter arise from that emission. The same kind of hollow sphere or orb, surrounding, for instance, the solar system, would answer the same purpose. Its sun, being in the centre of the orb, would have all its light reverberated back to it : except the comparatively small quantity intercepted by the planets : a great part of which quantity would, by direct, and indirect reflections, be returned to the sun ; and a quantity equal to the remainder, by means of volcanoes, and other internal fires in the planets, might be thrown off from them, and conveyed to the sun : whereby the equilibrium of the whole might be preserved.

Such an orb for a single system appears simple and plain ; and such an one for the whole choir of systems, though seemingly more complicated, might yet appear equally suitable for the purpose, when its structure, and the laws and principles which governed it, and also the situation of the several systems relative to it, and to each other, should become known.

Its stupendous extension would be no objection to the supposition of its reality : for if the convenience and pleasure of the inhabitants of Saturn were a sufficient reason for furnishing that planet with its massy ring, the preservation of such a choir of systems, with the astonishing multitudes of their inhabitants, would justify and sufficiently support the supposition of such an orb : especially when it is considered, that besides answering the grand purpose of preserving those systems, it might, perhaps

haps like Saturn's ring, be provided on both sides of it, with ample means of making it a suitable place for habitation : the habitation of myriads of millions of animate beings, equal or superior to those, which people our planetary system.

Beyond that orb, at proper distances, it is conceivable, there might be other concentric orbs, equally suitable for habitation, and alike inhabited : including within them innumerable systems of planets, resembling the solar system, and like that animated, and adorning the infinite expanse.

To this hypothesis objections may be made, and such as might prove it to be, like many an one which has preceded it, a mere philosophical revery. But before it be ranked in that class, I would ask, whether, if there be no such orb, nor any thing to answer a like purpose, the law of gravitation, that universal law, on which the philosophy of the immortal *Newton* is founded ; by which, with such admirable sagacity, he has explained the phenomena of material nature ; and on which he makes its preservation depend, will not finally bring on its dissolution ? Or rather, whether the operation of that law would not long ago have brought it on ?

The sun of our planetary system, and the suns (called fixt stars) of other systems, and therefore the systems themselves, do probably, according to astronomical observations, possess the same relative place ; or are, in respect of each other, fixt. But how are the exterior systems (supposing the whole not boundless) prevented from approaching towards the common centre of gravity : from which, if they have no revolution round it, (which the like observations make probable) they cannot be kept by a projectile or centrifugal force ? Must they not constantly by that law be drawn, with an accelerating motion,

tion, towards that centre ; and finally, with the whole choir of systems, directed by that law, arrive at it with successive tremendous crashes, until the destruction of the whole would be compleated ? And could any thing but the interposition of the Power which created them, prevent it ?*

If such a catastrophe would be the effect of that law, would it not demonstrate the wisdom, and foresight of the Creator, to suppose, he provided the means of counteracting that effect at the same time he ordained the law ? And among the possible means of doing it, is it not conceivable, that a hollow sphere or orb, analogous to that above-described, might be one ?

It has been suggested in what way such an orb might prevent the gradual waste and decay of the material system. Let us now see, whether it might not be applied to prevent the swifter and more dreadful catastrophe, to which the law of gravitation, in certain circumstances, seems capable of subjecting that system.

The described orb, like every other body, would possess the gravitating principle, in proportion to its quantity of matter : which, in different parts of the orb, might be more or less dense, as the effect, intended to be produced, might require. Where a strong attractive power might be necessary, the density would be greater ; and so, *vice versa* : and to assist or co-operate with it, a magnetic power might be superadded.

Thus

* Mr. *Whiston* observes, " It is by no means impossible, that all the bodies in the universe should approach to one another, and at last unite in the common centre of gravity of the entire system : nay, from the universality of the law of gravitation, and the finiteness of the world, in length of time, except a miraculous power interpose and prevent it, it must really happen." Discourse introductory to his Theory. p. 38.

Thus constituted, and furnished with those, and other need-ful qualities, and surrounding the whole visible choir of systems, might not the orb, by the principle of gravitation, either alone or assisted, keep those systems next to it, from being drawn towards the centre of gravity by their own, and the mutual action of the interior systems? And might not those several systems be so placed, and the densities of the bodies respectively belonging to them, with the densities of the surrounding orb, and consequently their mutual gravitating power, be so regulated, and adjusted, as to keep them all at the distance assigned them; and forever prevent their approximating, either to the centre of the general system, or to its surrounding orb: all of them together thus constituting an undecaying permanent whole?

It has been observed by philosophers, “that a body placed any where, within a hollow sphere, which is homogeneous, and every where of the same thickness, will have no gravity, wheresoever it be placed: the opposite gravities always precisely destroying each other.”* But that observation cannot be applied to the hollow sphere or orb, above-described: for by the description, it is not homogeneous.—Nor need it be of equal thickness: which, however, is a circumstance of no consideration, if equal thickness, with different degrees of density in different parts, would answer the purpose.

The phenomena of nature, upon the supposition of such an orb, would probably be the same, *cæteris paribus*, as now take place. Whether that supposition be supported by phenomena, and what other foundation there is for it, will be the subject of a future memoir.

* Chambers's Cyclopædia, under the word Gravity.



III. *Observations tending to prove, by Phenomena and Scripture, the Existence of an Orb, which surrounds the whole visible material System; and which may be necessary to preserve it from the Ruin, to which, without such a Counterbalance, it seems liable by that universal Principle in Matter, Gravitation.*

By JAMES BOWDOIN, Esquire,
President of the American Academy of Arts and Sciences.

AT the conclusion of a memoir, entitled, "Observations on Light, &c." which I have had the honour to lay before the Academy, it was intimated, that there are phenomena in nature, and other evidence, tending to prove the existence of an orb, that surrounds the whole visible material system.

The evidence is,—phenomena and scripture.

The phenomena are,—the luminous girdle in the blue expanse, called the Milky Way;—other luminous appearances in it; and the expanse itself.

In regard to the luminous girdle, or Milky Way.—This phenomenon has been supposed to result from the combined lustre of infinite multitudes of stars, too distant to be distinctly visible. But although it be observed through telescopes, that there is a great number of stars in the Milky Way, on which circumstance the supposition is founded, they appear as stars set in it; distinguishable from it; and not contributing to form the phenomenon.

The supposition not only disagrees with the appearance, but is inconsistent with every philosophical idea concerning those stars. They are represented to be suns: each having its system

tem of planets revolving round it; and consequently requiring a space proportioned to their number, and the extent of their systems: which space, for such multitudes of them as the supposition implies, must be beyond conception immense: and through which they must therefore be dispersed at such distances, that comparatively few of them could be visible by us; and that the whole together could not blend their light to cause that phenomenon.

On the contrary, the phenomenon strikes us, as it may be supposed such a luminous girdle would strike, if its light were reflected from the concave surface of a far distant orb: to which, on the hypothesis assumed, it had been propelled from the numerous systems, which the orb enfolds.

The same idea is suggested by the different degrees of its light, from a small light to a faint scarcely discernible one; by the frequent interruptions of it; and by the large chasm, which for a considerable space, makes the girdle appear double, and very irregular.

These appearances may be occasioned by the situation of the earth in respect to those parts of the orb, from which certain cones of light (presently to be explained) are reflected; and by the particular construction, and configuration of those parts; by means of which those cones are broken, and irregularly reflected to the earth: whose different situations in its orbit, by reason of its great distance from the orb, would occasion no sensible difference in the appearance.

With respect to the other luminous appearances in the concave expanse, I beg leave here to introduce several observations, upon that subject, from two authors, who have distinguished themselves in the astronomical branch of science.

One of them, Dr. *Smith*, in his *System of Optics*,* observes, that “*Hugenius*, in the year 1656, looking by chance through a large telescope, at three small stars, very close to one another, in the middle of Orion’s Sword, saw several more as usual. But the three little stars very near one another, (marked θ by *Bayer*) together with four more, shone out as it were through a whitish cloud, much brighter than the ambient sky: which being very black, caused that lucid part to appear like an aperture, which gave a prospect into a brighter region.. He viewed it many time, and found it continued in the very same place, and of the same shape as the figure represents; [See plate II. fig. 8.] and called it *Protentum cui certe simile aliud nusquam apud reliquas fixas potuit animadvertere.*”

He also observes, that “in the *Philosophical Transactions*,† there is an account of a later discovery of five more such lucid spots, though less considerable than this of *Hugenius*; the middle of which, we are there told, is at present in $\pi. 19^{\circ} 00'$, with south latitude $28^{\circ} 45'$; and that it sends forth a radiant beam into the south-east, as another in the girdle of *Andromeda* seems to do into the north-east. It is also there remarked, that though these spots are in appearance but small, and most of them but a few minutes in diameter; yet, since they are among the fixt stars, as having no annual parallax, they cannot fail to occupy spaces immensely great; and, perhaps, not less than our whole solar system: in all which spaces, it should seem, that there is a perpetual uninterrupted day.”

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* P. 447—8.

† No. 347 *Jones’s Abr.* vol. iv. p. 224.

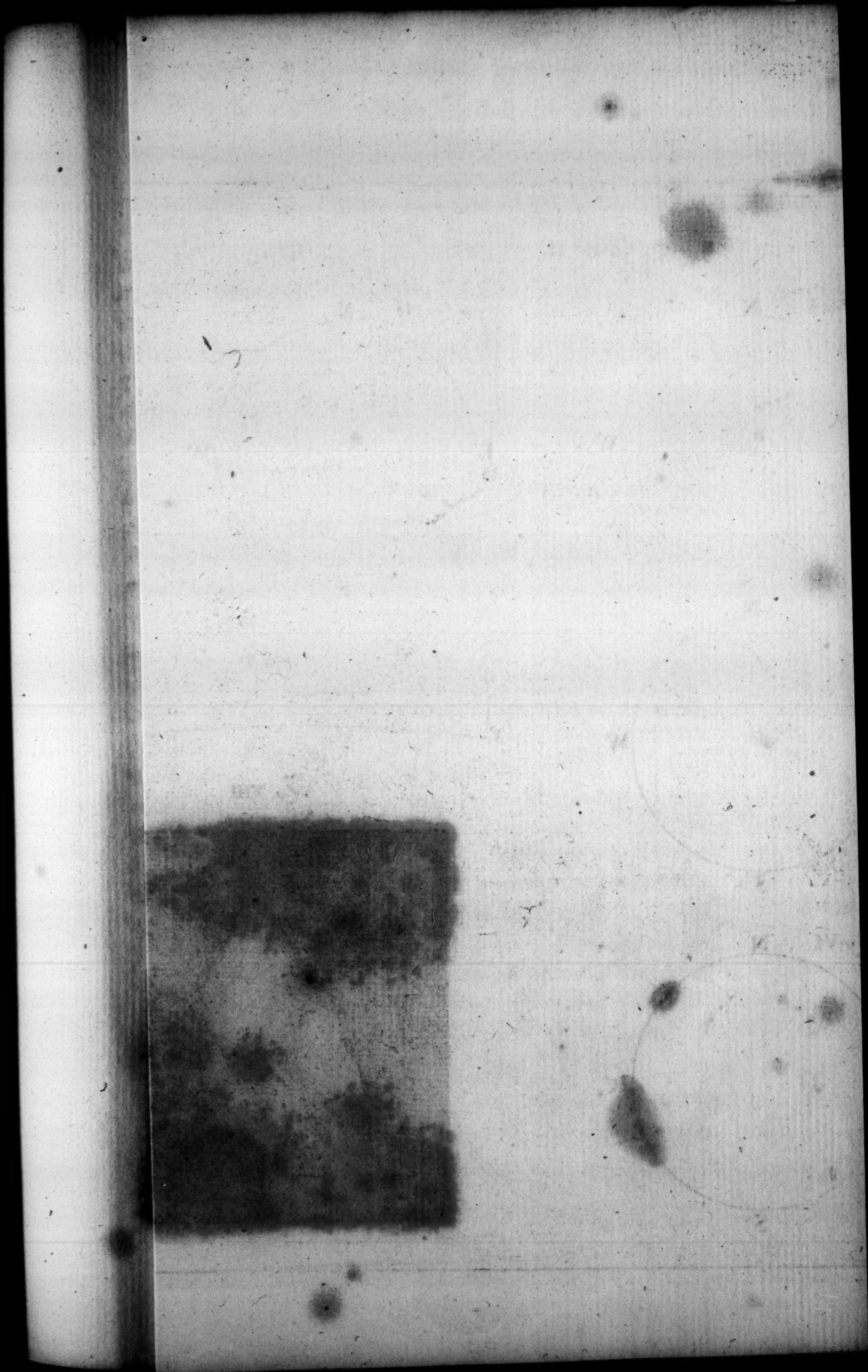


Plate II.

Fig. I.

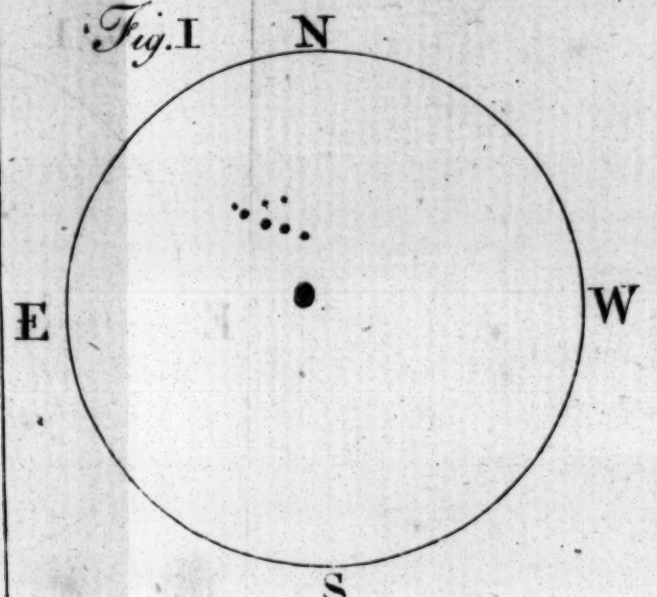


Fig. V.

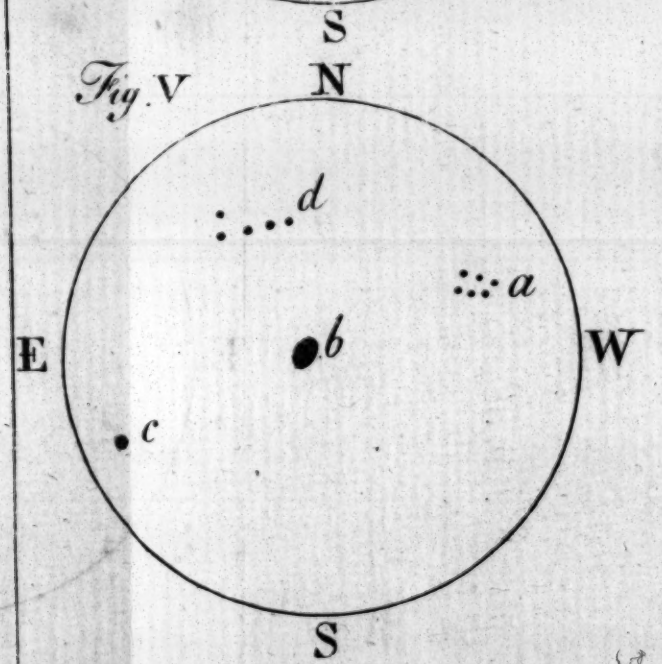
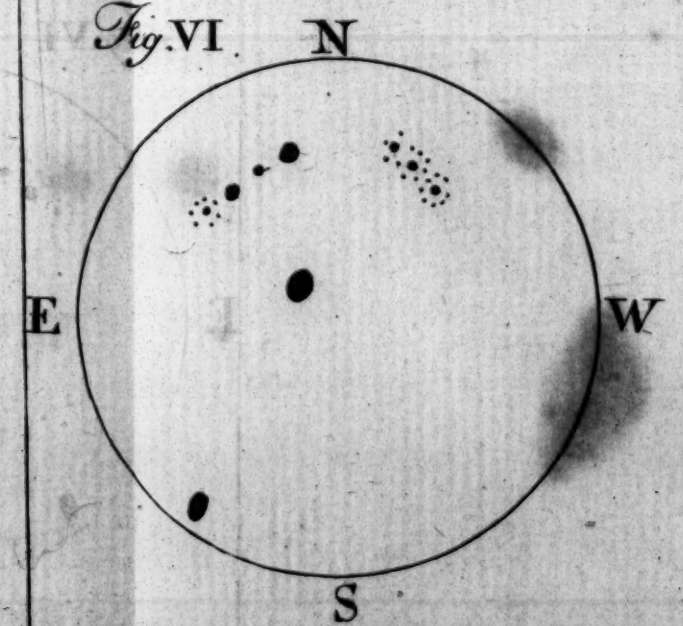


Fig. VI.



Facing p. 210

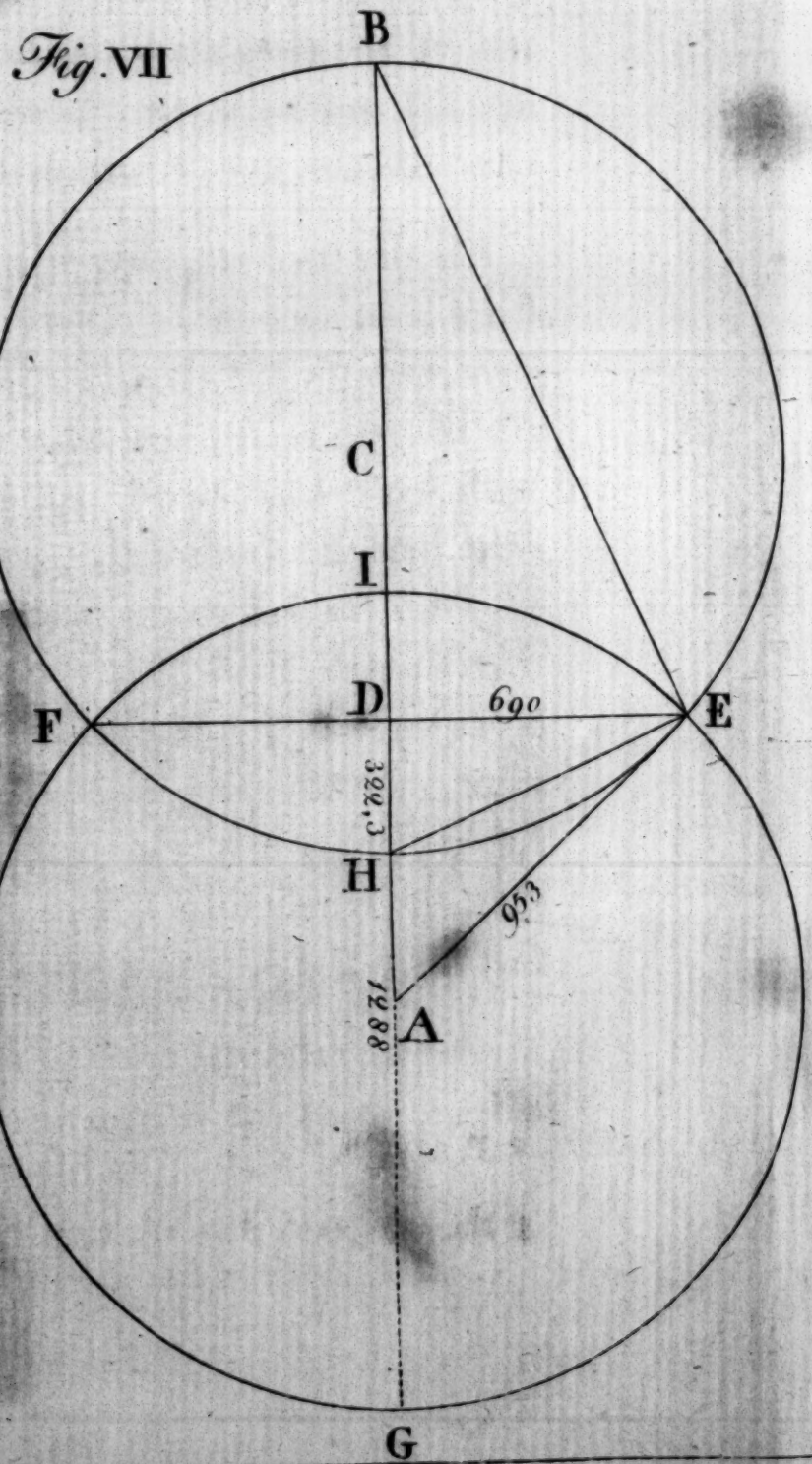
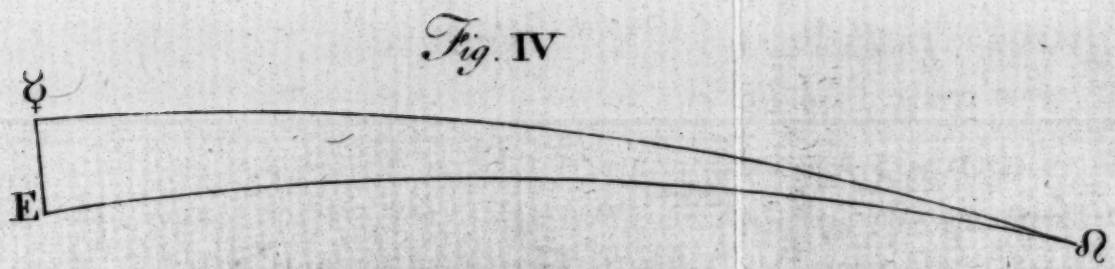
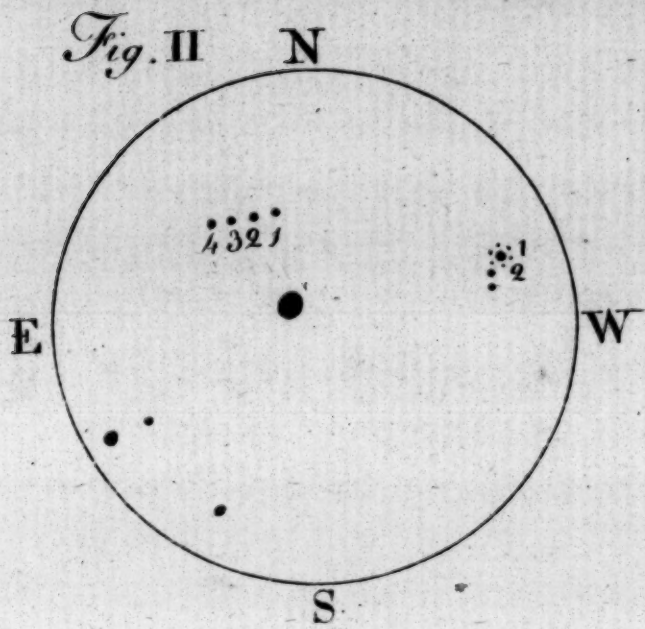
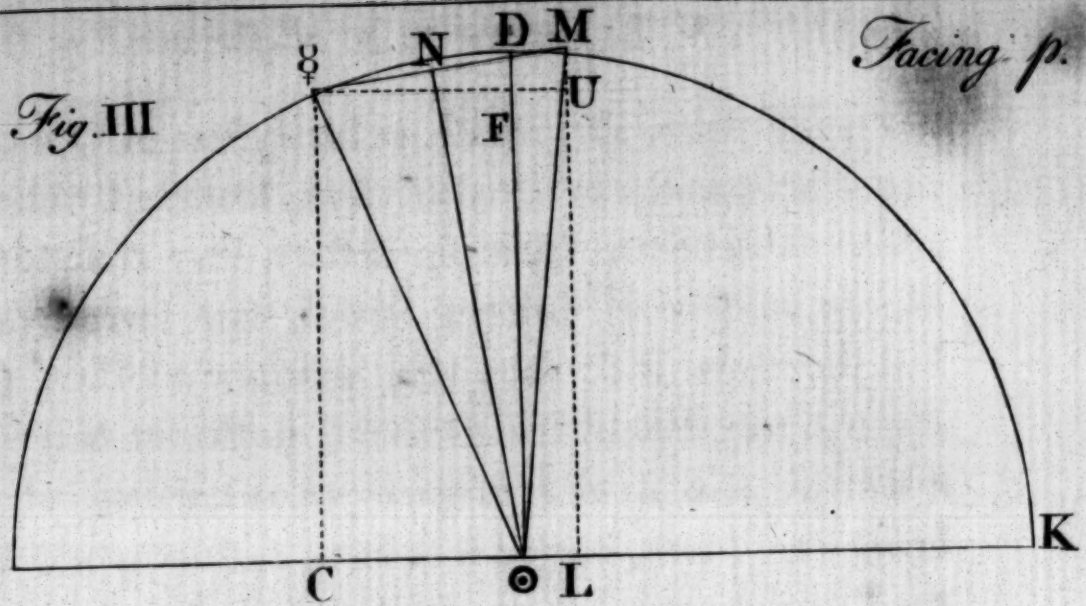
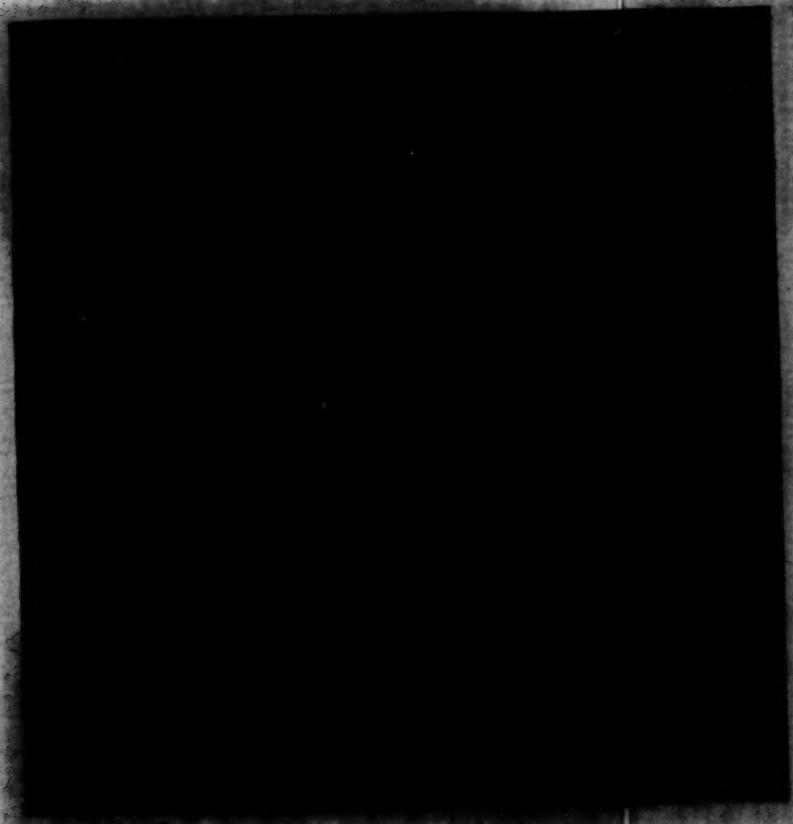
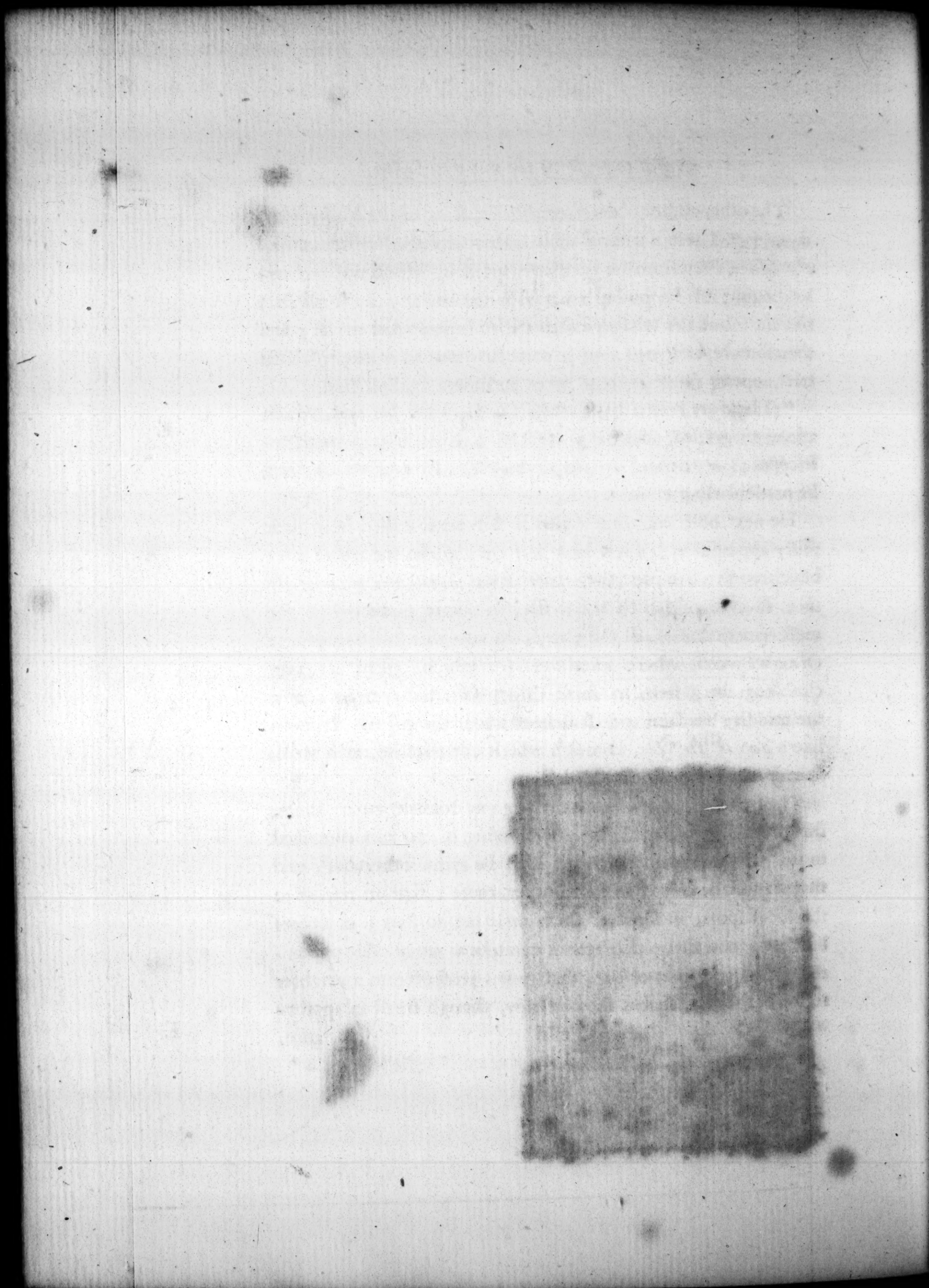


Fig. VIII





The other author, Mr. *Ferguson*, speaking of the Milky Way, says, † “ There is a remarkable tract round the heavens, called *the Milky Way* from its peculiar whiteness, which was formerly thought to be owing to a vast number of very small stars therein : but the telescope shews it to be quite otherwise ; and therefore *its whiteness must be owing to some other cause*. This tract appears single in some parts, in others double.”

“ There are several little whitish spots in the heavens, which appear magnified, and more luminous, when seen through telescopes ; *yet without any stars in them*.” Five of which spots he particularly mentions.

He next observes, that “ cloudy stars are so called from their misty appearance. They look like *dim stars* to the naked eye : but through a telescope, they *appear broad illuminated parts of the sky* ; in some of which is one star, in others more.—But the most remarkable of all the cloudy stars, is that in the middle of Orion’s Sword, where seven stars (of which, three are very close together) seem to shine through *a cloud very lucid* near the middle, but faint and ill-defined about the edges. It looks like *a gap in the sky*, through which one may see, as it were, *part of a much brighter region*.”

These quotations, without making any comment upon them, shew, that the Milky Way is not owing to the stars contained in it ; that the telescope shews it to be quite otherwise ; and that it must be owing to some other cause : that in respect to the lucid spots, in some of them there are no stars ; in others but few ; and that one of them exhibits a remarkable appearance of an aperture, or gap, that gave a prospect into a brighter region : that the spaces they occupy, though small in appear-

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† Astronomy. p. 339—40. Edit. 4th.

ance, are, perhaps, not less than our whole solar system; and that in them it should seem there is perpetual uninterrupted day.

From these phenomena it seems not improbable, that the Milky Way, and those lucid spots, are parts of a concave body or orb, of the same nature with some of the other heavenly bodies; and, whose light, transmitted to us, exhibits those phenomena, according to the laws and circumstances, which regulate it.

There is another, and still more remarkable phenomenon, that suggests the idea of such an orb: I mean the blue concave expanse, which surrounds, and appears to limit visible nature; and which is the last to be considered.

It is thus explained by Sir Isaac Newton; who observes, "that all the vapours, when they begin to condense and coalesce into natural particles, become first of such a bigness as to reflect the azure rays, ere they can constitute *clouds* of any other colour. This, therefore, being the first colour they begin to reflect, must be that of the finest and most transparent skies: in which the vapours are not arrived to a grossness sufficient to reflect other colours."*

By this explanation it appears, that the cause of this phenomenon exists within the earth's atmosphere. If it really doth exist within it, the phenomenon, from the assigned cause of it, seems to be nothing more than a blue transparent cloud, more or less extensive, in proportion as the atmosphere may happen to be less or more charged with other clouds.

If this were the cause, would not the heavenly bodies, in a clear sky, partake of the colour of that cloud, and appear blue, or be tinged with it, by means of their light passing through the

* *Chambers's Cyclopædia*, under the word *Blueness*.

the blue cloud? And would not this appearance indicate, that the blue rays of their light were transmitted, and the other coloured rays, for the most part, reflected from the atmosphere? Would not that transmission of the blue rays occasion all bodies around us to appear blue, so long as the atmosphere, continuing clear, should exhibit the blue cloud? And would not the colours of those bodies vary as other coloured clouds should succeed and predominate?

Would not this reflection of the other coloured rays occasion, not only a decrease of light, but, with respect to the sun, a great diminution of its heat? If the several different coloured rays do each, in respect to heat, produce an equal effect; and all but the blue rays are reflected, should we not, in a clear day, be deprived of six sevenths, or a proportionable part, of the sun's heat, which the seven sorts of rays, had they been all transmitted, would have afforded?

Such appearances and effects might have been expected, if the assigned cause produced the phenomenon: for the sun's light and other light, and also bodies in general, whatever be their colour, being viewed through a medium of any original colour, will appear of that colour, or strongly tinged with it. But it is apprehended, that no such appearances and effects have ever been observed; and, therefore, that there is reason to doubt the reality of the cause assigned: the insufficiency of which may further appear in the course of these observations.

But how is the existence of the orb deduced from the phenomenon?—In the same manner as the existence of the other heavenly bodies, and the existence of the bodies around us are deduced: namely, from the uniformity and permanency of their visible qualities, or phenomena.

In

In regard to bodies around us, whenever by sight we have been impressed with certain ideas of colour, form, and magnitude, corresponding to bodies near us, and at an approachable distance, we have found, by constant and uniform experience, derived also from, and confirmed by, every other sense and means of information, that such bodies do really exist: and having thus from experience gained the knowledge, that certain phenomena do infallibly indicate the existence of those bodies, the phenomena themselves do then alone become the undisputed evidence of that existence.

Nature is simple and uniform in its operations. From the same cause follow like effects; and these indicate the same cause. Bodies of every kind, through the medium of light, produce their respective phenomena, and these demonstrate the reality of those bodies.

From these principles we infer the reality of those terrestrial bodies, which, by reason of their situation and distance, can only be the objects of sight: and from the same principles we also infer the reality of the heavenly bodies, the planets, and fixt stars. If this last inference be just, is it not equally just to infer, from the same principles, the reality of the blue circumambient expanse: that is, that it is a real concave body, encompassing all visible nature: which is the exact description of the concave surface of the orb above-mentioned.

There is one appearance of the blue expanse, which may be thought to militate with the foregoing account of it.

In a clear day, it appears of a brighter blue than in the night, occasioned by the sun's light reflected to us by the earth's atmosphere. From which circumstance it might be supposed, that the cause of the phenomenon doth exist within the atmosphere,

phere, and is the atmosphere itself, or its vapour. It is apprehended, however, that this would be a mistaken supposition; and that the appearance may be explained on principles, which will not only invalidate the supposition, but further shew the insufficiency of the cause, to which the phenomenon has been ascribed.

For that purpose it may be observed, that the atmosphere being invisible, must be without colour; and has, perhaps for that reason, no greater disposition to transmit or reflect to us the blue rays of light, whether of the sun or stars, than those of the other colours: and, therefore, if the phenomenon be produced by means of the blue rays of those luminaries (which I shall attempt to explain) the atmosphere cannot be the cause of that production.

With respect to the vapours in the atmosphere, which, in a particular state, are said to occasion the phenomenon, they being of different degrees of grossness or density, must arrange themselves according to that density, or their specific gravity. If then any of the ranges consisted of vapour, in a proper state to transmit or reflect to the eye the blue rays only, the effect of it would be destroyed, or changed, by the grosser vapour in the lower range. Or if it should so happen (which seems very improbable) that the whole body of vapour should consist of particles of the due size, and in the proper state, to reflect the blue rays, it could not long continue in that state, by reason of the changeable nature of the vapour, and the numerous causes, that are constantly operating to produce a change in it. But the phenomenon is uniform and premanent; and therefore must be the effect of an uniform and permanent cause.

If

If these observations have any foundation, neither the atmosphere nor its vapour, assisted by, or assisting, the *direct* light of the sun and stars, can be the cause of the phenomenon.

The atmosphere, however, or its finer and transparent vapour, contributes to the brighter hue of the phenomenon by day : which may be thus explained.

The sun's light in its mixt state, reflected by the atmosphere, or by the transparent vapour floating in it, enters the eye at the same time with the blue light of the expanse ; and both together delineate on the retina an image, formed by their united rays, each producing its effect. The light from the expanse exhibiting the blue image ; the light from the sun illuminating or brightening the image ; and both together impressing the idea of that phenomenon, as it is displayed in a clear day.

If it should be asked, from whence the concave expanse derives its light, the answer is—from the numberless planetary or solar systems, which it includes : and particularly from those in the neighbourhood of it, which directly answer the purpose of enlightening, and in other respects, accommodating its inhabitants.

This light, transmitted to the expanse through its atmosphere, is reflected back directly and indirectly to the systems from which it issued : to be again, in a due succession, remitted to, and reflected from, the expanse. By such a reciprocation, and mutual interchange of light with each other, and among themselves, the several parts may be supplied with the quantity they had respectively emitted ; and the equilibrium of the whole maintained : whereby the evils, that might otherwise ensue from the waste, or undue distribution of its matter, and the consequent alteration of its gravitation, might be prevented.

To

To different systems, according to their situations, the expanse may exhibit very different phenomena. Although to our system, or to us on this planet, it exhibits the blue concave of an all-surrounding orb; which, in the Milky Way, and in some other parts of it, shines with a brighter light, it may to other systems appear of other colours; and exhibit to some of them in succession, according to their situations, the several primitive colours in the order, in which the rays of those colours are separated and classed.

Of one of these exhibitions, that of the blue colour, we have ocular demonstration. But why should the expanse appear to us blue, rather than green, or of any other primitive colour? If that appearance can be explained by the refrangibility of light, or by the separation of it into its several colours, as perhaps it can, the other appearances of the expanse to other systems, naturally, if not necessarily, follow.

Experiments prove, that light is compounded of differently coloured rays; and that after it has past through different mediums properly disposed, the rays are refracted, or separated and classed, according to their different refrangibility; and shew those colours in the order just mentioned: that the three most refrangible of them, the blue, the indigo, and violet, which possess one half of the space spread over by the whole, are so nearly allied in colour, that the last, when considerably spread, are scarcely to be distinguished from the neighbouring blue: for which reason, those three classes appear as one, at a great distance from the refracting medium: and the blue thus circumstanced, and uniting those classes, may therefore be said to possess a space equal to the space occupied by all the rest. That from any segment of a hollow sphere, such, for instance, as a

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concave mirror, whose arc does not exceed fifteen or eighteen* degrees; the cylinder of rays falling upon it parallel to its axis, will, if there be no refraction, be reflected to a focus round that axis: the focus being nearly equidistant from the pole of the segment, and the centre of its sphere: and that those rays, if previously refracted, and classed into their several colours, will, in their divergence from the focal point, shew those colours in a reversed order: the refraction, however, occasioning an alteration in the position of the focus, and the diverging cone.

To apply some of these observations, it may be supposed, that the interior side of the expanse has, in general, an uniform surface, which may be conceived as composed of a multitude of segments, each of them not exceeding a given arch: that it is furnished with an atmosphere, possessing, in some peculiar mode, the power of refracting light, of distributing its rays into their respective classes, and transmitting them to the expanse; which also may be conceived as assisting, by its reflecting power, in their classification: that the transmitted rays would, in their classed state, be reflected from it in all directions; and that such of them (by far the greatest † part of the whole) as should come

*s *Gravesande's Natural Philosophy.* Book III. ch. xv. prop. 813.

† That these parallel rays (parallel, I mean, to any and every conceivable diameter-line of the expanse) must constitute the greatest quantity or proportion of the reflected light, will be manifest from these considerations:—That they come to every segment or part of the expanse from the opposite part of it, and from the systems situated between such opposite parts: that the distance of any two opposite parts from each other, equal to the diameter of the expanse, is the greatest that can take place within it: that there must, therefore, be, in the space between them, a greater number of systems supplying the expanse with light, than there can be in any

come to the atmosphere in parallel lines, or in cylinders, whose axes were diameter-lines of the expanse, and whose bases were equal to those segments, would pass through the atmosphere to the corresponding segments of the expanse, and be reflected from them; and afterwards, in the same classed state, unite in a focus, from which they would diverge, and exhibit their several colours.

To give some idea, though an imperfect one, of that focus, the reflection and convergence may be conceived as made (somewhat in the manner above-represented) from the segments composing the whole surface of the expanse: that each segment would reflect a cone of rays, terminating in a focus; and that the united *foci* of those cones, which must be considered as coming from all quarters of the expanse, would constitute its general focus.

In some such disposition, and state of things, as here represented, it is conceivable, that the system-light, transmitted to the expanse through its atmosphere, might be reflected from those segments; and for the most part converge in cones towards a general focus: where, by means of the refraction and separation, it had undergone in that transmission and reflection, it would be, in each cone, arranged or classed, according to the different refrangibility and reflexibility of its rays. After the rays had past the boundary of their focus, they would intersect each other, and form new and reversed cones, or conic

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figures:

any extra-central direction; and that this may be affirmed of every two opposite parts or segments in the whole surface of the expanse. The effect of the atmosphere, in regard to the refraction, is not here noticed. These rays, like the sun's rays at the earth, are considered as parallel, by reason of the great distance of the radiant bodies, and the consequent extreme minuteness of the angle of divergence at such a distance.

figures : in which each sort of the coloured rays, as before the interfection, would generally be together ; and in that associated state, continually diverge in proportion to their distance from the line of interfection.

But perhaps the whole of this effect, the classification of the rays, may be caused by the reflecting power of the expanse : which, in that case, would receive the rays in the same mixed state as the direct solar light comes to the earth : with respect to which, we know that it frequently undergoes a classification by reflection, as well as by refraction.

In either case, as the three most refrangible, and reflexible classes, at a proper distance from the focus, are not to be distinguished from each other, but all appear blue : and as the blue, at that distance and beyond it, doth therefore possess so large a portion of the interior space of the expanse, it is conceivable, that many systems may be so placed, as to be on all sides in the direction of the rays of that colour ; and to which the whole expanse would, for that reason, appear blue.

With respect to the earth, it is probably so situated as to be in all parts of its orbit, principally within the limits of such classes as are composed of the blue rays ; and partly within the verge of classes, whose rays, by reason of their imperfect separation being in a mixed state, exhibit a brighter light. The predominant colour, therefore, of the expanse, as it respects the earth, is blue ; with interspersions of a brighter light, such as the Milky Way, and other lucid parts of the expanse : whose irregular appearance, in the Milky Way, may be owing (as hath been already suggested) to the particular construction and configuration of its parts : the brightness of which seems to

intimate

intimate some peculiarity in their constitution, and in the circumstances attending them.

Nature thus exhibiting, on a broad scale, phenomena, which our little experiments can exhibit only in miniature; and of which those experiments sometimes lead to a happy explanation.

Whether the foregoing be such an explanation, or wholly chimerical, in reference to the colour of the expanse, does not affect the expanse itself: whose existence, considered as an all-surrounding orb, may be real, although the assigned cause of its colour be demonstrably without foundation.

From the several phenomena above-mentioned, unless the evidence supposed to arise from them be futile, or inadmissible, there is reason to conclude, that an all-surrounding orb doth really exist; and that the blue expanse is that orb.

It is an observation of Sir *Isaac Newton*, "that the main business of natural philosophy, is to argue from phenomena, without feigning hypotheses; and to deduce causes from effects, till we come to the very first cause, which certainly is not mechanical; and not only to unfold the mechanism of the world, but chiefly [among others that are mentioned] to resolve these, and such like questions, viz. Whence is it, that the sun and planets gravitate towards one another, without dense matter between them? and what hinders the fixt stars from falling upon one another?"*

Agreeably to the foregoing observation, the author of this memoir having adduced certain phenomena, he hopes not impertinently, has endeavoured, not only to argue from them, and to deduce the cause from the effects, but to resolve that great question

* *Opticks*. p. 344. 4th edit. 8vo.

question concerning the fixt stars, and the heavenly bodies in general, namely, What hinders them from falling upon one another, and thereby involving the whole in ruin?—Whether his endeavours have been successfully applied, those who are conversant in subjects of this nature, are best qualified to judge.

In regard to the subject in hand, there seems to be a happy co-incidence between phenomena and scripture; and, therefore, in further evidence of such an orb, and in evidence of several other orbs similar, and concentric to it, we may recur to scripture: several passages of which appear applicable to that purpose.

It seldom happens that natural philosophy is made to borrow assistance from thence: but though scripture may not be intended to instruct us in the philosophy of material nature, it may nevertheless give, and be intended to give, some hints of its constitution, or general system.

As the passages referred to, do not need any laboured comments, a very few observations will suffice to explain and apply them.

A remarkable one, and which may serve, in some measure, to elucidate the rest, is this passage, “It is God that buildeth his stories in the heavens.”* In the *English* translation, which agrees with the *French*, with the *Latin* of *Castellio*, and of *Tremellius* and *Junius*, the marginal-reading, referring to stories, is spheres and ascensions. The former explanatory of stories: the latter, another word for the *Hebrew*; and which answers to the *Greek* of the *Septuagint*. All which, both separately and together, give the idea of a succession of concentric spheres, ascending one above another, like the stories of a magnificent building:

* *Amos*, ch. ix. 6.

Building : and, agreeably to that idea, though on very different principles, perhaps those of the *Ptolemeian* system, the text has been explained.*

This construction, which appears to be a natural one, gives a meaning to the text,—a meaning illustrative of the omnipotence of the Architect : and, at the same time it elucidates some other texts relative to the subject, it is perfectly descriptive of the concentric spheres, or orbs, above-mentioned.

The same idea is intimated in the short account given of the creation by *Moses*, who seems to refer to two firmaments.—The first he mentions is limited to the earth and its atmosphere ; and the other is that in which the fixt stars do appear.

It is this latter, that is here to be considered : concerning which, “ God said, let there be lights in the firmament of heaven ;” and concerning which it is declared, that “ God set those lights in the firmament.”||

The radix of the *Hebrew* word, translated firmament, “ is applied to God’s spreading out the sky ; to the firmament, or spacious

* *Qui edificat in coelo* (in supremis coelis) attentiones suas—sphaeras suas—gradus suos : i. e. orbis coelestes, qui sunt velut gradus ; unus supra alterum.

Poli synopsis in loc.

|| Gen. ch. i. v. 14. 17.

Mr. *Whiston*, whose explanation of the *Mosaic* account of the creation is natural, and in general seems to be just, makes no distinction of firmaments : which, however, he might have made, without injuring his theory ; and which his own rules of interpretation would have justified.

The upper firmament, or blue expanse, in which the heavenly bodies were “ set,” he might have included, together with them, in the work of the fourth day, or year, as it was rendered visible at the same time, by means of the earth’s atmosphere, in that year, becoming transparent : which atmosphere, according to his theory, is the [other] firmament, or expanse. He supposes, the earth had no rotation about its axis until the deluge ; and, therefore, that its annual revolution round the sun, would occasion the antediluvian day to be exactly commensurate with the year.

spacious extension, which is spread abroad between the earth and the clouds: *as also to that other firmament, or spacious extension, which is above the clouds, where the heavenly bodies are placed.*"*

The original word † means, not only firmament, but expanse, or spacious extension. In the *English* translation, and also in the *Greek* of the *Septuagint*, it conveys the idea of something firm and solid. Some other translations adopt the other acception of it. It seems to include both; and in that case means something solid, and spaciouly extended.

This explication of the term, connected with the appearance of this firmament, or expanse, gives us the intimation of a solid and spaciouly extended orb, or sphere: and answers to one of the stories, which God built in the heavens.

"The heavens ‡ declare the glory of God: and the firmament sheweth his handy-work."—Here is a clear distinction between the heavens and the firmament. By the former, are meant the heavenly bodies; and by the latter, the firmament, or expanse, in which they appear.

The same observations may be applied to this, as have been applied to the foregoing passage.

Another, and more descriptive of such an orb, is the following one: "Hast thou spread out the sky: which is strong, and as a molten looking-glass:"|| or, as a mirror made of polished

* *Taylor's Hebrew Concordance*, root 1826.

† The author of this memoir, being unacquainted with *Hebrew*, speaks of its meaning by information only.

‡ Psalm xix. 1. Cælum hoc stelliferum. Poli Syn.

|| *Job* xxxvii. 18. An expandisti cum eo (eum adjuvando) æthera, vel cælos, vel firmamentum? Hoc græci vocant stereōma quod—firmum sit, et suâ se velut virtute

ished metal. The forementioned *French* and *Latin* versions, and the *Greek* of the *Septuagint*, do, in this passage, all concur with the *English*, in representing the sky as strong, firm, and solid. The *Septuagint* especially, expresses this idea with peculiar force; as doth also the *Hebrew* original: which, in this place, resembles the sky to a *speculum*, or mirror, “made of polished metal.”*

“The elegant simile of the mirror cannot be understood without recollecting, that their looking-glasses (or mirrors) were made of metal highly polished.”†

This description shews the sky to be, not only firm and solid, but remarkably adapted to reflect light; and so far intimates the cause, why it is visible. The sky here, as the firmament in a former clause, corresponds to one of the stories, which God built in the heavens.

There are other passages, which mention the spreading out, and stretching out, of the heavens; and this as declarative of the discretion, the understanding, the wisdom, and power of God. But if it be a mere appearance, arising from the atmosphere-vapours, in a particular state reflecting to us the blue rays of light; or if it be a mere circumstance attendant on, or resulting from, the atmosphere; and doth not indicate the real ex-

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virtute contineat, nullâ re nitens. Æthera, vel cœlos—quî solidissimi—quî sunt sortes: item sicut speculum fusum, sive concretum.—Cœlos, quibus *firmitas* tribuitur Prov. viii. 28. unde poetæ cœlum vocârunt kalkeon ouranon. Specula fusa intellige ex ære vel chalybe.—Vox *sortes* soliditatem denotat.—Cœlum,—solidissimum ut simul cohereat. Poli Syn.

* Fusum, firmum, validum, instar fusi et consistentis metalli. *Taylor's Hebrew Concordance*, root 783. 26.

† *Scott's Book of Job*, p. 354.

istence of what is declared to be thus spread or stretched out, it is then, in a comparative view, but an inferior instance of wisdom and power : by no means such an instance of them as to entitle it to be mentioned in the climax, in which it is found : much less to be the head, or principal member, of it.

The following, which is one of those passages, and in the sense of which the aforementioned versions concur with the *English*, will shew the climax.—“ He hath made the earth by his power : he hath established the world by his wisdom ; and hath stretched out the heavens by his understanding.”*—The earth, including its atmosphere—the world, or heavenly bodies collectively—the stretched-out heavens, or blue expanse. This remarkable climax, ascending in dignity and importance, shews, that the last and principal member of it, the expanse, is not only distinct from the earth, and the whole system of heavenly bodies, but that it surpasses them in excellence ; and that it is the capital, among the works of the visible creation. The description of it, and its rank in the climax, indicate, that it is the same firmament or expanse, above-described ; that the same observations are applicable to it ; and therefore, that this, and the parallel passages alluded to, may be adduced in further evidence of its existence ; and, consequently, of the existence of an all-surrounding orb.

The same idea is held forth in a part of the address of wisdom in Prov. viii. 27—29 : the sense of which may be expressed in the following translation ; which differs from the common *English* translation, no further than the apprehended sense of the text makes necessary. A few explanatory notes are interspersed, by way of illustration.

Wisdom

* Jer. ch. li. 15.

Wisdom speaking, says,—verse 27. “When God prepared the heavens [the whole system of visible nature], I was present. When (with respect to the heaven) he set an orb around the superficies of the depth [the immense space included within the orb : in reference to which, that space may be justly called the depth] : v. 28. When he gave solidity and strength to (that orb) the sky above ; and when he established its fountains of waters [its interior and exterior atmospheres] : v. 29. When (with respect to the terraqueous globe) he gave to the sea his decree, that its waters should not pass their bounds : and when he appointed the foundations of the earth, then I was by him.”

If this translation and illustration, be just, the text, which only gives the great out-lines, or capital parts of creation, strongly impresses the idea, that there is an orb surrounding all visible nature ; that it is strong and solid ; and that it is furnished with an interior and exterior atmosphere : all which is further descriptive of one of the stories, that God built in the heavens.

In support of the translation and illustration here given, I had collected, in a marginal note, a number of authorities from *Pool's Synopsis* : but it being somewhat long, and those who are qualified to judge in the matter, being able to recur to the *Synopsis*, it is omitted.

Beside those authorities, and in further support of the translation, may be adduced the 148th psalm : where are enumerated, in a regular succession, the heavenly bodies, which compose the material system :—the sun, moon, stars, heavens, and waters above the heavens.

The distinct notice there taken of those bodies, and the arrangement of them according to nature, make it probable, that by the heavens (in that passage, as in some others) are intended the orbs, that have been described. And, in regard to the waters above the heavens, they do plainly intimate, that those orbs are each, like the earth, environed by an atmosphere replenished with waters, to answer the same purposes with the atmospheric waters of the earth.—Of that passage, there will presently be occasion to take some further notice.

If some happy genius, well versed in *Hebrew*, and the philosophy of nature, would arrange in due order, and faithfully translate, those parts of scripture, that in any respect refer to the constitution and economy of nature, and this with a view of reconciling them to nature, we should probably find, that scripture philosophy and natural philosophy would mutually illustrate each other. Such a translation and illustration would be a real acquisition to science; and might lead to discoveries, of which, at present, we can form no idea.

One quotation more, amidst a further number that might be offered, will close the evidence.

“The heaven, and the heaven of heavens, and the earth also, are the Lord’s.” “Thou hast made heaven, the heaven of heavens, with all their hosts: the earth, and the seas, and all things in them.” “Praise him, ye sun and moon, ye stars, ye heavens of heavens, and ye waters above the heavens.”*

There are other passages of like import: but these containing all the varieties of expression I have observed concerning the material heavens, or system of nature, may be thought sufficient.

That

* Deut. x. 14. Neb. ix. 6. Ps. cxlviii. 3, 4.

That the material heavens are here intended, there can be no room to doubt, as they are mentioned in connection with the earth—with their hosts—with the earth and seas, and the things contained in them—with the sun, moon and stars—and with the waters above the heavens. They are evidently considered here as forming, in conjunction with those other bodies, one vast system; whose several constituent parts are, in the last clause of the quoted text, ranged in the order, in which it is natural to speak of them; and in which, reckoning from the centre of our solar system, they do in reality exist.

Here is a plain discrimination between the heaven; the heaven of heavens; and the heavens of heavens: which must imply some essential difference between them. To suppose the contrary is to confound language, and involve it in uncertainty. It would be to suppose those expressions void of meaning; and would be treating scripture with the indecency, to which no other book, appearing to be dictated merely by common sense, would be entitled. Those expressions, then, necessarily imply some essential difference in the objects of them: and what that difference is, the quotation from *Amos* points out. The gradation, respecting the heavens, is remarkable; and without recurring to any thing else, suggests the idea of stories in them, orb beyond orb, as above explained. The series too, in which they are mentioned—the sun, moon, stars, heavens, and waters above the heavens—and the place they hold in the series, suggest the same idea: which is strengthened and confirmed by the express declaration, that in fact there were such stories built by the Almighty: or, as it is otherwise expressed, that “he made them with all their hosts.”

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The last member of the series is the waters above the heavens. These waters, arguing from analogy, seem to indicate, and to be descriptive of atmospheres, that surround those orbs, amply provided, like our atmosphere, with waters, and other elements, proper for the support of animal and vegetable life; and for other important purposes.

The number of those stories, or concentric orbs, seems indefinite. The gradation clearly denotes a plurality of them: each having its hosts—its suns and planets, or systems. The ample spaces between them, like the space infolded by the orb, to which we more immediately belong, are beautified by those glorious bodies, which, within each of the orbs, constitute systems innumerable, serving the like noble purposes, which our solar system is calculated to serve, and doth serve.

The foregoing passages of scripture thus interpreted, appear to agree, in their result, with the phenomena above-mentioned; and, like them, to be naturally, and without force, applicable to the purpose, for which they were produced. Such agreement, it is apprehended, shews the propriety and fitness of the interpretation: as, on the other hand, a disagreement with phenomena would prove the unfitness or falsity of any interpretation; and manifest it to be totally inadmissible.

When scripture and phenomena thus agree, they mutually elucidate each other; and, in that case, what is deducible from the one, is confirmed by the other. As, therefore, those passages agree with the phenomena, they both together corroborate the evidence, which each afforded separately, of the existence of an interior orb.

With respect to the exterior orbs, the evidence for them must rest on scripture. There can be no phenomena, from which

which to deduce their reality : unless the aperture, or gap aforementioned, with what it discloses, be admitted as such.

The phenomena, exhibited through that aperture, are indeed remarkable ; and may indicate an exterior orb, or the bright region between that, and the orb, which more immediately surrounds us : in which bright region, as well as in some other of the lucid spaces in the expanse, there seems to be an uninterrupted and perpetual day.

If in fact there be such an aperture, the same appearances with those, from which it was deduced, may indicate other apertures in the other lucid spaces, and in the Milky Way : for the ascertaining of which, the observations of the ingenious Mr. *Herschell*, with his largest magnifiers, should he think proper to apply them for that purpose, might happily conduce.

Among the purposes, for which those apertures were intended, if they really exist, this may be one,—to give to the *intra-orbic* and *trans-orbic* systems some intimation of each other, and of their mutual relation ; and to afford them a glimpse of the grand complicated system, of which they are parts.

The immensity of those orbs doth not invalidate their existence : on the contrary, immensity is so congenial to our ideas of the Creator, and his works, that it affords, as applied to those orbs, an internal presumptive proof of their reality.

On the supposition of their existence, what an assemblage of glorious bodies do they exhibit ! peopled by an unlimited variety of beings, and arranged in a gradation beautiful and astonishing ! Trace the gradation from the smaller to the larger planets, circling around their sun, and with him forming a magnificent system ! Trace it from that system, through successive systems, to their surrounding orb ! Trace it from orb to orb,

orb, and through their several hosts of systems up to the superior orb, and its ambient atmosphere ! Trace it in every possible direction, from the common centre to the utmost verge of that atmosphere, and the most wonderful phenomena, in a rapture-inspiring succession, strike the mental eye ! impressing the idea of a complete whole, self-balanced, and held in union by universal gravitation ! exhibiting a superlatively grand system of systems, embosomed in the infinite, all-comprehending essence of the Creator !

Grand and magnificent as this system is, there may be another incomparably more so ; composed of myriads of such systems, governed by the same laws, and with it surrounded by an immense orb, to counter-balance the gravitation of the included systems.

That other system may be a part of a still more splendid one, formed on the same plan ; and this latter may enter into the composition of other systems, beyond comparison superior to it ; each succeeding system, in a regular progression, rising in dignity and splendour. And thus we may go on, enlarging our idea of those systems, indefinitely.

What is there to check that idea, when we consider the infinity of space, in connection with the infinite wisdom, power and benevolence of the Author of nature ; and at the same time reflect, that infinite space is the proper, and the only adequate theatre for the display of those perfections, and of such a character ?

This hypothesis, by introducing solid orbs, may possibly, on a superficial view of it, be thought a revival of the ancient or *Ptolymeian* System, and to grow out of it. But on the contrary, it will be found, upon examination, totally inconsistent with

with it ; and to be in reality the offspring of the new philosophy : derived from the grand principle of that philosophy—universal gravitation.

Upon the whole :—The hypothesis, so far as it relates to the existence of the interior orb, immediately surrounding the visible heavens, the author of it apprehends to be a probable deduction from the principle of gravitation ; and to be deducible also from phenomena and scripture. He offers it for consideration, with the hope, that if it should appear not wholly groundless, it may be productive of a happier illustration.



What the new, I am endeavouring to do before the Society as part of an account of the uncommon darkness which took place of West-India. The time of this extraordinary darkness was May 10, 1780. It came on between the hours of ten and eleven A. M. and continued until the middle of the next night ; but with different appearances at different places. As to the manner of its approach it seemed to appear first of all in the W. The wind came from that quarter, and the darkness appeared to come on with the clouds that came in that direction. The day was so which the darkness stole, was a faint in different places. In most parts of the country it was so great, that people were unable to read common print—determining the time of day by their clocks.

IV. *An Account of a very uncommon Darknefs in the States of New-England, May 19, 1780. By SAMUEL WILLIAMS, A. M. Hollis Professor of Mathematics and Philosophy in the University at Cambridge.*

THE best method to promote the knowledge and science of nature, is to proceed by way of observation and experiment. The general course, productions, and laws of nature, should be carefully and steadily attended to : and when any new phenomena appear, all the circumstances and effects, relating to them, should be particularly noted and collected. In this way we shall be most likely to arrive at the knowledge of their causes : or, at least, we shall prepare those materials which may enable posterity to determine, with certainty and precision, on what at present may be but imperfectly understood.

With this view, I shall endeavour to lay before the Society, as particular an account as I can collect, of the uncommon darknefs which took place in the states of *New-England*.

The *time* of this extraordinary darknefs, was May 19, 1780. It came on between the hours of ten and eleven, A. M. and continued until the middle of the next night ; but with different appearances at different places. As to the *manner* of its approach it seemed to appear first of all in the S. W. The wind came from that quarter, and the darknefs appeared to come on with the clouds that came in that direction. The *degree* to which the darknefs arose, was different in different places. In most parts of the country it was so great, that people were unable to read common print—determine the time of day by their
clocks,

clocks or watches—dine—or manage their domestic business, without the light of candles. In some places, the darknefs was so great, that persons could not see to read common print in the open air, for several hours together : but I believe this was not generally the case. The *extent* of this darknefs was very remarkable. Our intelligence, in this respect, is not so particular as I could wish : but from the accounts that have been received, it seems to have extended all over the *New-England* states. It was observed as far east as *Falmouth*.—To the westward, we hear of its reaching to the furthest parts of *Connecticut*, and *Albany*—To the southward, it was observed all along the sea-coasts :—and to the north, as far as our settlements extend. It is probable it extended much beyond these limits, in some directions : but the exact boundaries cannot be ascertained by any observations that I have been able to collect. With regard to its *duration*, it continued in this place at least fourteen hours : but it is probable this was not exactly the same in different parts of the country. The *appearance* and *effects* were such as tended to make the prospect extremely dull and gloomy. Candles were lighted up in the houses ;—the birds having sung their evening songs, disappeared, and became silent ;—the fowls retired to roost ;—the cocks were crowing all around, as at break of day ;—objects could not be distinguished but at a very little distance ; and every thing bore the appearance and gloom of night.

Such were the general appearances or phenomena of this extraordinary darknefs. I shall now mention such particular observations as I have been able to collect, which were either made on this phenomenon, or seem to relate to it.

With regard to the state of the atmosphere preceding this uncommon darkness, it was universally observed for several days before, that the air appeared to be full of smoke and vapour. The sun and the moon appeared remarkably red in their colour, and divested of their brightness and lucid appearance; and this obscuration increased as they approached nearer to the horizon. This was observed to be the case in almost all parts of the *New-England* states, for four or five days preceding the 19th of May. The winds had been variable; but chiefly from the S. W. and N. E. The thermometer from 40° to 55° . The barometer rather high for this part of *America*,—from 29 inches 80, to 30 inches 50. The weather had been fair and cool for the season.

As to the state of the atmosphere when the darkness came on, it was observable, that the weight or gravity of it was gradually decreasing the bigger part of the day. This may be inferred from the observations that were made in this place by the Rev. Professor *Wigglesworth*, and Mr. *Gannett*. At 12^h they found the mercury in the barometer stood at 29 inches 70. At 12^h 30', the mercury had fallen the $\frac{1}{100}$ part of an inch. At 1^h it was at 29 inches 67. At 3^h it was at 29 inches 65. At 8^h 8' it was at 29 inches 64. I made a course of barometrical observations similar to these, at the same time, in a different part of the state. I was then at *Bradford*, about thirty miles north of this place, nearly under the same meridian, or rather a little to the east. At 6^h A. M. I found the mercury in the barometer 29 inches 82. As soon as the darkness began to appear uncommon, I observed the barometer again, and found the mercury at 29 inches 68: this was at 10^h 20'. At 10^h 45', the darkness arose to its greatest degree in that part of the country; and the mercury was then at 29 inches 67. The dark-
ness

ness continued in the same degree for an hour and an half. At 12^h 15', the mercury had fallen to 29 inches 65; and in a few minutes after this, the darkness began to abate. The mercury remained in this state until evening, without any sensible alteration. At 8^h 30', it seemed to have fallen a little; but so small was the alteration, that it was attended with some uncertainty; nor could I perceive that it stood any lower at 11^h 30'.

Both these barometers appear to be very good instruments. That used in this place was made by *Champney*: that which I used was made by *Nairne*: and they may both be depended on as to the accuracy of their construction. It may, however, be proper to observe, that the house where I made my observations, stood at least forty or fifty feet higher than that in which the observations were made here.

And from these observations it is certain, that on the day when the darkness took place, the weight or gravity of the atmosphere was gradually decreasing through the whole day.*

The colour of objects that day, was also worthy of remark. It is mentioned, in the observations made by the gentlemen here, that "the complexion of the clouds was compounded of a faint red, yellow, and brown; and that, during the darkness, objects, which commonly appear green, were of the deepest green, verging to blue; and that those which appear white, were highly tinged with yellow." Much the same observation was pretty generally made. Almost every object appeared to me to be tinged with yellow rather than with any

other
 * *Farenheit's* thermometer, at *Bradford*, at 6^h. A. M. was at 39°. At 12^h. it stood at 51°. At 9^h. P. M. it was at 46°.—At *Cambridge*, at 12^h. it was at 51½°. At 3^h. P. M. it stood at 51°.

other colour. This I found to be the case with every thing I held up to view, whether near, or remote from the eye.

Another thing that deserves our attention is, the nature and appearance of the vapours that were then in the atmosphere. Early in the morning, the weather was cloudy: the sun was but just visible through the clouds, and appeared of a deep red, as it had for several days before. In most places thunder was heard several times in the morning. The clouds soon began to rise from the S. W. with a gentle breeze; and there were several small showers before eight o'clock: and in some places there were showers at other times, throughout the day. The water that fell was found to have an uncommon appearance, being thick, dark and sooty. A gentleman, who was then at *Ipswich*, observes, that "he found the people much surprized with the strange appearance and smell of the rain-water which they had saved in tubs. Upon examining the water, I found (says he) a light scum over it, which rubbing between my thumb and finger, I found to be nothing but the black ashes of burnt leaves: the water gave the same strong sooty smell which we had observed in the air." The same appearance was observed in many other places: and it was very remarkable on *Merrimack-River*. Large quantities of scum, or black ashes, were found floating upon the surface of the water, that day. In the night, the wind veered round to the N. E. and drove it towards the south shore. When the tide fell, it lay along the shore at the width of four or five inches. This I found to be the case for five or six miles;—and probably it was the case for many more. I examined a considerable quantity of this matter; and in taste, colour and smell, it very plainly appeared to be nothing more than what the gentleman observed at *Ipswich*,—

wich,—the black ashes of burnt leaves, without any sulphureous, or other mixtures.*

Being apprehensive whether there was not some uncommon matter in the air that day, I put out several sheets of clean paper in the air and rain. When they had been out four or five hours, I dried them by the fire. They were much sullied, and became dark in their colour; and felt as if they had been rubbed with oil or grease. But upon burning them, there was not any appearance of sulphureous or nitrous particles.

The motion and situation of the vapours in the atmosphere, was also worthy of notice. In most places it was very evident that the vapours were descending from the higher parts of the atmosphere towards the surface of the earth. A gentleman, who was then at *Pepperrell*,† mentions a very curious observation, as to their *ascent* and *situation*. “About nine o’clock (says he) in the morning, after a shower, the vapours rose from the springs in the low lands, in great abundance. I took notice of one large column that ascended with great rapidity, to a considerable height above the highest hills, and soon spread into a large cloud; then moved off a little to the westward. A second cloud was formed in the same manner, from the same springs, but did not ascend so high as the first: and a third was formed from the same places, in less than a quarter of an hour after the second. About three quarters of an hour after nine o’clock, these clouds exhibited a very romantic appearance. The upper cloud appeared of a *redish* colour; the second appeared,

* The same was observed at *Concord* and *Dover* in *New-Hampshire*: at *Berwick*, and many other places in this state.

† Mr. *Eames*, a Tutor in the University.

peared, in some places, *green*; in others, *blue*; and in others, of an *indigo* colour: the third cloud appeared almost *white*." One of the gentlemen who observed here, mentions a circumstance of somewhat a singular nature.—“While the darkness continued (says he) the clouds were in quick motion, interrupted, skirted one over another; so as apparently, and I suppose, really, to form a considerable number of *strata*: the lower *stratum* of an uniform height as far as visible;—that height conceived to be very small from the small extent of the visible horizon, and from this circumstance observed in the evening;—Being in the street, I saw a person with a lighted torch, which occasioned a reflection of a faint red light, similar to a faint *Aurora Borealis*, at a small height above my head. The height at which the reflection appeared to be made, was not more than from twenty to thirty feet.”—And it was generally remarked, that the hills might be seen at a distance in some directions, while the intermediate spaces were greatly obscured and darkened.

From these observations, it seems as if the vapours, in some places, were ascending; in most, descending; and in all, very near to the surface of the earth. To this we may add, that during the darkness, objects appeared to cast a shade in every direction: and that, in many places, there were several appearances or corruscations in the atmosphere, not unlike the *Aurora Borealis*: but I do not find that there were any uncommon appearances of the electric fire any where observed that day.*

Having

* In several accounts it was also mentioned, that a number of small birds were found suffocated by the vapour. “A number were found dead in several of the new towns, round the houses; and some flew into the houses, as I have been told by eye-witnesses.” Extract of a letter from *Dover*, in *New-Hampshire*.

Having mentioned the phenomena, with such observations upon them, as I have been able to collect, I shall now endeavour to account for the cause of this unusual appearance.

From the observations that have been mentioned, we may conclude with much certainty, that the atmosphere, on the 19th of May, was charged with an uncommon quantity of vapour. That this was the case, is evident from the large quantity of smoke and vapour that appeared in the atmosphere for several days before; which was so great, as to darken the sun and moon, and render all objects, at a distance, of a dull and very hazy appearance. It was also evident, from the descent of those large quantities of soot, or black ashes, which, through a long extent of country, were found mingled with the rain that fell, and floating on the surface of the waters. And the cause from whence the uncommon quantity of these vapours was derived, is easily ascertained. It is well known, that in this part of *America*, it is customary to make large fires in the woods, for the purpose of clearing the lands in the new settlements. This was the case this spring, in a much greater degree than is common. In the county of *York*, in the western parts of the state of *New-Hampshire*, in the western parts of this state, and in *Vermont*, uncommonly large and extensive fires had been kept up. The people in the new towns had been employed in clearing up their lands this way, for two or three weeks before: and some large and extensive fires had raged in the woods for several days before they could be extinguished. In addition, therefore, to what arises from evaporation, and those exhalations which are constant and natural, a much larger quantity of vapour arose from those large and numerous fires, which extended all around our frontiers. As the weather had been clear, the

air heavy, and the winds small and variable for several days; the vapours, instead of dispersing, must have been rising and constantly collecting in the air, until the atmosphere became highly charged with an uncommon quantity of them.

A large quantity of the vapours, thus collected in the atmosphere, on the 19th of May, were floating near the surface of the earth. Wheresoever the specific gravity of any vapour is less than the specific gravity of the air, by the laws of fluids, such a vapour will ascend in the air. Where the specific gravity of a vapour, in the atmosphere, is greater than that of the air, such a vapour will descend: and where the specific gravity of the vapour and air are the same, the vapour will then be at rest,—floating or swimming in the atmosphere, without ascending or descending. From the barometrical observations it appears, that the weight or gravity of the atmosphere was gradually growing less, from the morning of the 19th of May, until the evening. And hence the vapours, in most places, were descending from the higher parts of the atmosphere, towards the surface of the earth. From the observation made at *Pepperrell*, it appears, that in some places the vapours were ascending, until they arose to an height in which the air was of the same specific gravity; where they instantly spread, and floated in the atmosphere:—and this height was not much above the adjacent hills. From these observations, we are lead to conclude, that the place where the vapours were balanced, or became of the same specific gravity as the air, must have been very near the surface of the earth. And hence we may observe,

That such a large quantity of vapour, floating in the atmosphere, near the surface of the earth, might be sufficient to produce

duce all the phenomena that were observed May 19, 1780.— Thus the *direction* in which the darknefs came on, would be determined by the direction of the wind; which accordingly was observed to be from the S. W. The *degree* of the darknefs would depend on the density, colour, and situation of the clouds and vapour; and the manner in which they would transmit, reflect, refract, or absorb the rays of light. The *extent* of the darknefs would be as great as the extent of the vapour: and the *duration* of it would continue until the gravity of the air became so altered, that the vapours would change their situation, by an ascent or descent. All which particulars will, I think, be found to agree very exactly with the observations that have been mentioned. Nor does the *effect* of the vapours, in darkening terrestrial objects, when they lay near the surface of the earth, appear to have been greater than it was in darkening the sun and moon, when their situation was higher in the atmosphere.

Upon the whole, it is evident, that the atmosphere was charged, in a high degree, with vapours; and that these vapours were of different densities, and occupied different heights. By this means the rays of light falling upon them, must have suffered a variety of refractions and reflections; and thereby become weakened, absorbed, or so far reflected, as not to fall upon objects on the earth in the usual manner. And as the different vapours were adapted by their nature, situation, or density, to absorb, or transmit, the different kind of rays, so the colours of objects would appear to be affected by the mixture and prevalency of those rays that were transmitted through so uncommon a medium.

In what has been said, I have endeavoured to explain what I take to be the cause of the late unusual darkness. I would not, however, be understood to assert, that there could not be any other causes or circumstances which might join to produce this unusual appearance. Possibly there might be causes and circumstances of this nature, of which we have no suspicion. But as the uncommon quantity and situation of the vapours in the atmosphere might be sufficient to account for the phenomena, it appears to me to be unnecessary to look out for other causes, or to go into a particular examination of the various conjectures that have been advanced upon this subject.

It may not be amiss to observe, that such appearances, and from the same cause, have been observed before, in this part of *America*. In the *Philosophical Transactions*, N^o. 423, there is an account of a remarkable darkness, which took place October 21, 1716, O. S. It is said, "The day was so dark, that people were forced to light candles to eat their dinners by. Which could not be from any eclipse, the solar eclipse being the 4th of that month." This observation was made by Mr. *Robie*, a man of great ingenuity, and formerly a Tutor in the University : but there is nothing said as to the cause, or any other particulars. Several persons have informed me, that they remember an uncommon darkness in the year 1732, August 9, O. S. and which was afterwards found to be occasioned by an uncommon fire in *Canada*. It is to be wished, that we could find something more particular upon this subject.

There was also a remarkable darkness at *Detroit*, October 19, 1762, much like that of May 19 ; of which we have this account, by the Rev. *James Stirling*, *Phil. Trans.* for 1763, vol. liii. p. 63. "Tuesday last, being the 19th inst. (i. e. of
"October)

“ October) we had almost total darknefs for the moft of the
 “ day. I got up at day break. About ten minutes after, I ob-
 “ served it got no lighter than before. The fame darknefs con-
 “ tinued until nine o’clock, when it cleared up a little. We
 “ then, for the fpace of about a quarter of an hour, faw the
 “ body of the fun, which appeared as red as blood, and more
 “ than three times as large as ufual. The air, all this time,
 “ which was very denfe, was of a dirty yellowifh colour. I
 “ was obliged to light candles to fee to dine, at one o’clock,
 “ notwithstanding the table was placed clofe by two large win-
 “ dows. About three, the darknefs became more horrible ;
 “ which augmented until half pafte three, when the wind breez-
 “ ed up from the S. W. and brought on fome drops of rain,
 “ or rather fulphur, and dirt ; for it appeared more like the
 “ latter than the former, both in fmell and quality. I took a
 “ leaf of clean paper, and held it out in the rain, which ren-
 “ dered it black whenever the drops fell upon it ; but, when
 “ held near the fire, turned to a yellow colour ; and when
 “ burned, it fizzed on the paper like wet powder. During this
 “ fhower, the air was almoft fuffocating with a ftrong fulphu-
 “ reous fmell.—It cleared up a little after the rain.”

“ There were various conjectures about the caufe of this na-
 “ tural incident. The *Indians*, and vulgar among the *French*,
 “ faid, that the *English*, which lately arrived from *Niagara* in
 “ the veffel, had brought the plague with them. Others ima-
 “ gined, it might have been occafioned by the burning of the
 “ woods : but I think it moft probable, that it might have
 “ been occafioned by the eruption of fome volcano, or fubter-
 “ raneous fire, whereby the fulphureous matter may have been
 “ emitted in the air, and contained therein, until, meeting with
 “ fome

“ some watery clouds, it has fallen down together with the
“ rain.”

We have another account of this phenomena, in a letter from an officer, who was then at *Detroit*, to a friend at *Wilmington*, in *Pennsylvania*. “ The 19th of this month, (October, 1762) “ was the most extraordinary dark day, perhaps, ever seen in “ the world. At nine in the morning, it was scarce lighter “ than at break of day, and so continued till about twelve “ o'clock,—the air being very full of smoke, accompanied with “ a strong smell, as of wood, straw, and other combustibles, “ when burning. At half an hour after one, it was so dark “ that we were obliged to light candles to dine by. At this “ time it rained a little ; with which fell a quantity of black “ particles, like ashes, as turned every thing it fell upon black. “ Even the river (which is twice as wide as *Christiana* in *Penn-* “ *sylvania*) was covered with black froth ; which, when scum- “ ed off the surface, resembled the lather of soap, with this “ difference, that it was (and as black as ink) more greasy. At “ seven in the evening, the air was more clear, and the disagree- “ able smell was now almost gone. We have since been in- “ formed, by people who were twenty miles from hence that “ day, that the darkness, rain, and smell, was the same with “ them.”

There does not appear to have been any thing to support the conjecture of a *volcano*, *subterraneous fires*, and *sulphureous matter*. In all other particulars, the phenomena agree to those that were observed among us, and seem to be derived from the same cause.

*Felix, qui potuit rerum cognoscere causas,
Atque metus omnes et inexorabile fatum
Subjecit pedibus.*—————

V. *An Account of the Effects of Lightning on two Houses in the City of Philadelphia. In a Letter from the Hon. ARTHUR LEE, Esq; F. A. A. to the Hon. JAMES BOWDOIN, L. L. D. Pres. A. A.*

Philadelphia, July 29, 1781.

S I R,

TWO houses, in this city, have been lately struck with lightning, attended with phenomena that are curious, and may be useful ; I therefore flatter myself, that an account of them will be agreeable to your Society.

On the 26th June, 1781, about ten o'clock at night, a large house in Market-street, called *Mrs. House's*, occupied by several Members of Congress, was struck by lightning, which entered through the ceiling of the garret, leaving what appear exactly like two bullet-holes. It then glanced along the door, tracing its passage by a blackish line, in an oblique direction, to an iron hinge ; and passing from the uppermost hinge to the lowest, pierced thro' the ceiling into the room below ; where, meeting immediately with the bell-wire, it was conducted by it, through all the chambers down two stories, till it ended at the bell, which hung over a back door near the kitchen ; and its conductor ending there, it split the door to pieces. From this bell there was a wire which should have gone to the street door, but was broke : yet where the bell-handle (which was iron) ended upon the frame of that door, the nearest pannel was split to pieces. It is therefore supposed, that this was a separate portion of the electrical fluid, which was attracted by the iron rod which formed the bell-handle out-side of the door.

The

The house was shingled, and one shingle appeared loosened. A man was in bed in the garret directly under where the fluid entered, and must have been smitten by it, had not the iron hinge drawn it from that direction to itself. The hinge was two feet from one hole, and two feet and an half from the other in an oblique direction. The angle, at the corner of the hinge nearest the holes, was left very bright; and, probably, that angle operated as a point to attract and receive the electrical matter. The wire, in many places, was melted; and, dropping, burnt the floor. One of the gentlemen, who was in bed in one of the rooms, leaping out upon the floor, burnt the soles of his feet, where they touched the wire. To others, the wire seemed to be in flames, and a sulphureous smell remained in the chambers. The house is higher than any that was near it, situated on the south side of the street;—has no point, or conductor, fixt to it;—was struck at the western and eastern ends; and the back door, which communicated with the bell-wire, is on the south side. The other that was struck, was at the eastern end.

On the 8th of July, 1781, the wind being at the northward of west, but variable, the house of Dr. *Shippen*, jun. [Plate III. Fig. 1.] was also struck, in a manner that will be best understood by the enclosed sketch, or ground-section, [Fig. 2.] of the house; though, to comprehend it, we must suppose, that the course of the wire, represented by the dotted lines, is along the ceiling, instead of the floor, as is here represented. The traces of the lightning, that appear in the house, (for there are none outside) are these.—At the place where the broken wire ends in the passage, and is coiled up at *k*, the plaister is beat off, about the size of a large hand expanded, to the brick wall, which is uninjured. Between the bells, *a* and *b*, the ceiling is raised and cracked, in a straight direction,

rection, from one to the other, but not fallen off. At the front door, in the corner, about two feet from the floor, the plaister is broke off, as at *n*, in the other end of the passage: but there is an apparent trace of the lightning on the bricks, in a blueish mark. There is no communication between this and the wire, which runs along the ceiling over it sixteen or seventeen feet distant; nor any iron near, except it be the back of the fire-place on the other side of the wall, opposite to where the plaister is beaten off. In the dining-room, the wire is melted from *o* to *p*, and again from *q* to *r*; all the remainder being entire, and the rest of the wire, in the other parts of the house, and the outside, uninjured. The pieces of wire that fell on the floor, burnt deep holes in it. The conductor being examined, was found to be in good order; but the point, which was copper, was melted so as to form a sort of button; which had not that degree of brightness, which those, skilled in the fusion of copper, say this metal preserves for some time after its having been melted. This effect upon the point appears, therefore, to be of an older date. The conductor is about half an inch diameter,—enters about two feet into the ground, and is fixt to the wall by six iron staples; none of which are nearly opposite to the wire in the dining-room. Mrs. *Shippen* felt an electrical shock as she stood in the passage up stairs, with her hand on an iron latch. These are the facts;—and the electricians here differ in their opinions, about the manner of the electrical fluid's meeting with the bell-wire. Some think it descended through the conductor; but being in a greater quantity than the earth would immediately receive, part quitted the conductor, and passed through the wall to the wire nearest the conductor. The wire being melted in that part, seems to lead to this opinion:

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but

but it is also melted in a remoter part ; which seems to shew, that it was owing to partial defects in the wire : and if the fluid had quitted the conductor, it would naturally have passed off by the staples that enter the wall, and shewn its effects in various parts, as they directed. The other opinion is, that it was conducted down the wet roof of the kitchen, which is of shingles, unto the corner, where, at *d*, it met with the bell-wire on the outside of the wall ; when part went into the dining-room, and another part into the kitchen ; and passing from the first bell to the second, (which is about a foot from the first, while the third is between two and three feet off) and by its wire was conducted into the passage to the coil, at *k*, where it took to the wall, and passed away. The stroke at the front door, must have been from a separate source : for it does not, on a minute examination, appear probable, that it penetrated through the wall of the dining-room at the corner, *o*, (where the crank of the bell-wire is fastened to the wall by a small iron nail, entering about two inches) and so from that, passed to the wire in the passage, which continues from thence to the front door. Not the least sign of injury appears upon the roof of the landry ; nor externally, upon any part of the house.

From these observations we may conclude, that the manner in which the bell-wires are distributed in a house, is of great moment ; and that they ought always to be disposed with a view to the possibility of their becoming conductors. From the plaister being destroyed, and the bricks uninjured, it would seem that brick is a conductor, and therefore carried off the fluid without any further effect. That the points of conductors should be examined from time to time ; because, in the state in which that of Dr. Shippen's house was found, and had probably

bably been for some time, it would by no means answer the end of putting it up. That a conductor on each corner, or on each chimney of a house, especially if of any size, is necessary, to guard it compleatly.

A. L E E.

P. S. Supposing that the fluid came to the uppermost crank of the wire, at *d*, first, it would seem that it did not part with that wire, in any portion, to go to the other, which ran close to it, and entered through the same holes; nor even to that which goes into the parlour, and is attached to it, but kept to the same wire till it ended; which is conformable to what we see in experiment.

A section of Dr. *Shippen's* house, which must be supposed to be that of the upper parts at the ceiling, in order to understand the course of the bell-wires, and the passage of the electrical fluid.

a, The bell in the kitchen, which answers to the parlour and dining-room, by the wire which pierces the kitchen wall at *d*, and runs outside of the passage wall to that of the dining-room, which it pierces at *e*, and is continued to the chimney, ending at *f*.—The portions of it, between *o p*, and *q r*, having been melted by the electrical matter.

b, The bell which answers to the front door: but the wire was broken at *l*, and hung down upon the wall, ending in a coil at *k*. The bell *b*, is alineated with the bell *a*, and much nearer to it than the third.

c, The bell which answers to the bed-chambers up stairs, by the faint dotted line, which pierces the wall with the first wire;

H h 2

runs

runs outside with it, and is fixt in the wall, in the corner, by a crank, which is about three inches below that of the dining-room, or first wire; and when it has pierced the wall into the dining-room, at the corner, *e*, makes a short turn, and passes through the ceiling up to the chambers. At *g*, a wire goes off to the parlour.

n, The place where the plaister was beat off in the passage at the front door; as it was at the other end of the passage, directly under the coil, at *k*.

s, Suppose to be the roof of the kitchen, ending directly over, and about twelve feet above the crank of the wire, *d*.



VI. *An Account of the Effects of Lightning on a large Rock in Gloucester. In a Letter from the Rev. ELI FORBES, to the Rev. MANASSEH CUTLER, F. A. A.*

Gloucester, July 3, 1783.

REVEREND SIR,

ON the 18th of March, 1782, we had a most severe clap of thunder, and its effects were most surprising. A large rock, of the contents of near ten feet square above ground, received the full weight of its shock. It struck the rock near the top, and made an impression like that of a cannon-ball. It broke off near twenty pounds of the solid stone, and cracked the remaining body in several directions, though not very deep. Then it ran down on the western side of the rock in three directions, or main branches,—each branch marking its path with a chalky colour, tinged with blue. The lightning so penetrated the solid stone, as to alter the texture of its parts, and change its colour an inch deep; which still remains on a large piece of the rock now by me. When these three branches reached the ground, they took different routs.—One, that seemed to contain the greatest quantity of the fluid, took its course northward, rending the ground, and throwing up cart-loads of earth when it met with large rocks. Some large rocks, whose surfaces were nearly on a plain with the earth, it passed over, with only marking its path, about an inch and an half wide, with the same colour as on the rock it struck first: then it entered the ground, and tore up the turf about an inch deep. At a rock in its way, which rose some inches above-ground, it divided itself into two equal branches, turning up the turf from the

the basis of the rock, till they met on the opposite side, and passed much the same course, till it came to another rock, not quite so high, nor of so wide a base. At this rock it entered the ground, and raised it from its bed about three inches, tho' it was of several tons weight; which was the last effects I could discover of it.

The second main branch, which seemed to contain the next greatest quantity, took its rout westward by a stone wall; on the north side of which was a bank of snow, about six inches deep, and which was now in a watery state. It followed this wall under the snow, rending and removing some of the foundation-stones, and undermining others. Though it passed chiefly on the north side of the wall, under the snow, yet it was not confined to that side; for it crossed under it several times, before it got to the distance of fifty yards. Then it divided itself into two branches; and one turned off southward, across a piece of grass-land, a little descending towards the south, about two rods; which brought it upon a plain, or level, with the ridge of a barn, which stood on a beach near the sea-side, about fifty rods distant from the above-said grass-plot. It entered at the west end, just below the peak,—passed on the under side of the ridge-pole to a king-post, where it again divided into two branches; one ran down the post like an engraver's tool, within four feet of the ground, where about one third part of the post was hewed off; and on the opposite side was a spike, which was just entered into the wood, and stood horizontal:—it passed round the post to the head of the spike;—passed over the head,—drilled a small hole,—returned along the spike to the post, and then, splintering it, continued its course to the ground, and no further traces appeared. The other branch continued its course
on

on the ridge-pole to the end ;—ran down a principal to a corner post, which it pushed down, rending the board which covered it. In its way to the ground it left the post, and passed over two iron bolts that hung a gate to the post, leaving a frosted tract on them ;—returned to the post again, and continued to the bottom, which rested on a flat stone ; and then passed across the beach, about six or eight rods, throwing up the ground and pebble-stones, till it came to the water's edge, and no further effects could be seen. The other branch, at the wall, continued its course by it, producing similar effects as before it divided, until it came near a pond of water, when it entered the ground, and broke out near the water's edge, making a small hole, and could be traced no further.

The third main branch, at the rock first struck, bent its course eastward. In some places it plowed deep furrows in the earth,—throwing up large quantities of earth and stones, and threw some stones, of twenty pounds weight, to the distance of four rods. In other places, it only marked its path as a lambent flame, without removing the lightest bodies that lay in its way, continuing its course to a small collection of water, and there ceased.

A number of persons, within the circle of two hundred yards, very sensibly felt the shock. Those that were abroad were thrown to the ground, and remained senseless some minutes : those that were in the adjacent houses, felt an effect, or shock, like that of electricity ; by which some parts of the body suffered more than others. A young woman, who was leaning with her elbow against a jamb of a chimney, felt it struck numb, and remained so for some hours ; and, when it began to recover, it was in very great pain. Another woman was sitting with
her

her feet upon a hearth, who felt a violent shock across her legs, and her feet and about half way of her legs remained insensible for some time.

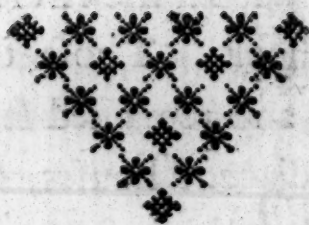
Thus, Sir, I have given you the particulars of the surprising operations of the lightning; and you may depend on all that I have related to be fact, as I critically examined the whole the next day, and made minutes of the same, while on the spot: And you may communicate as much of it as you please to your learned Society.

I am, Sir, &c.

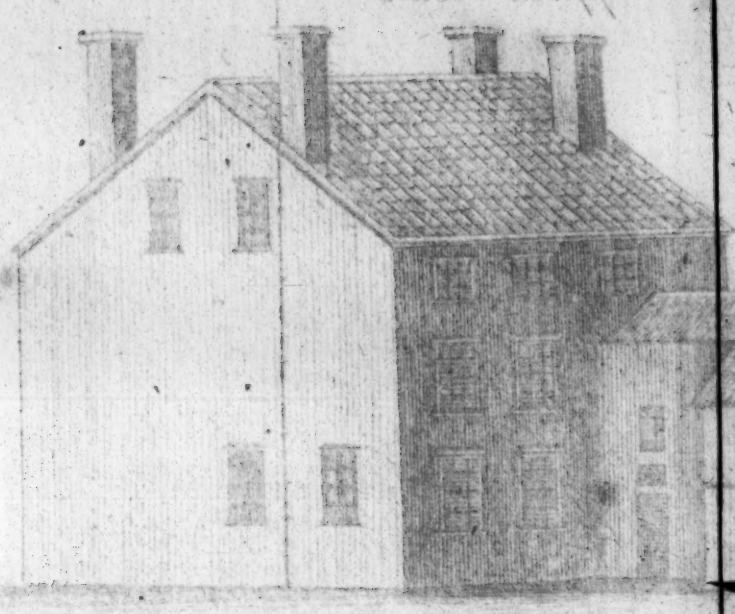
ELI FORBES.

Rev. Mr. Cutler.

N. B. I have enclosed an imperfect sketch, [Plate III. Fig. 3.] which may assist you in forming your ideas of the various courses of the lightning.



View 3



Back view of Doc. Shippens House

Fig. I

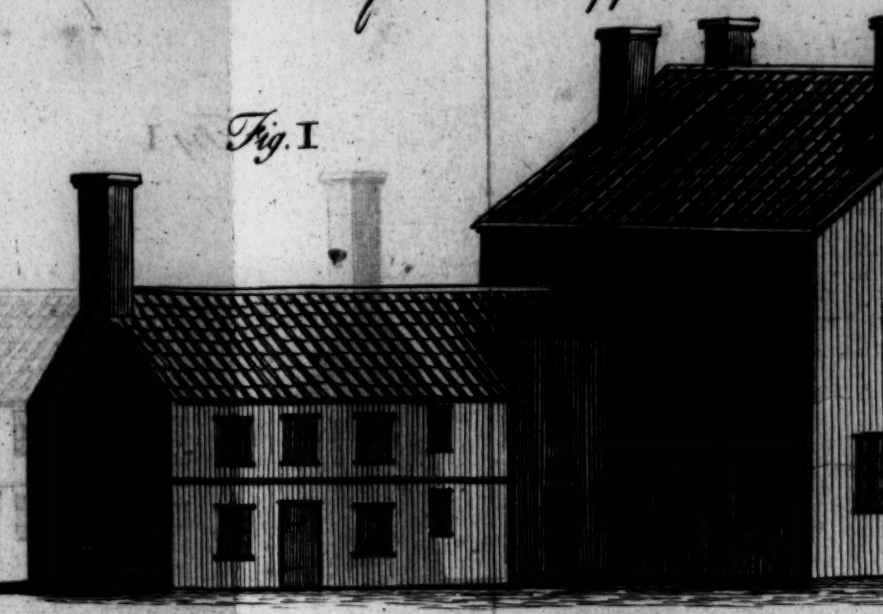
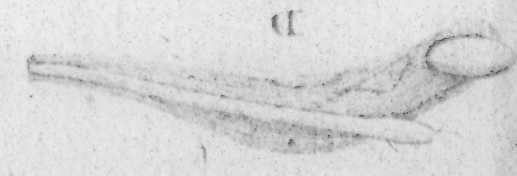
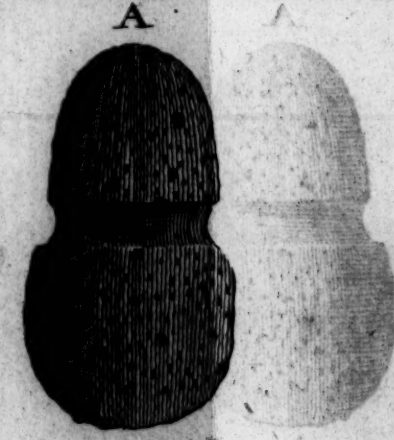
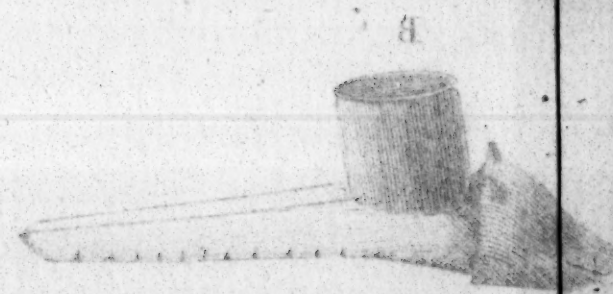
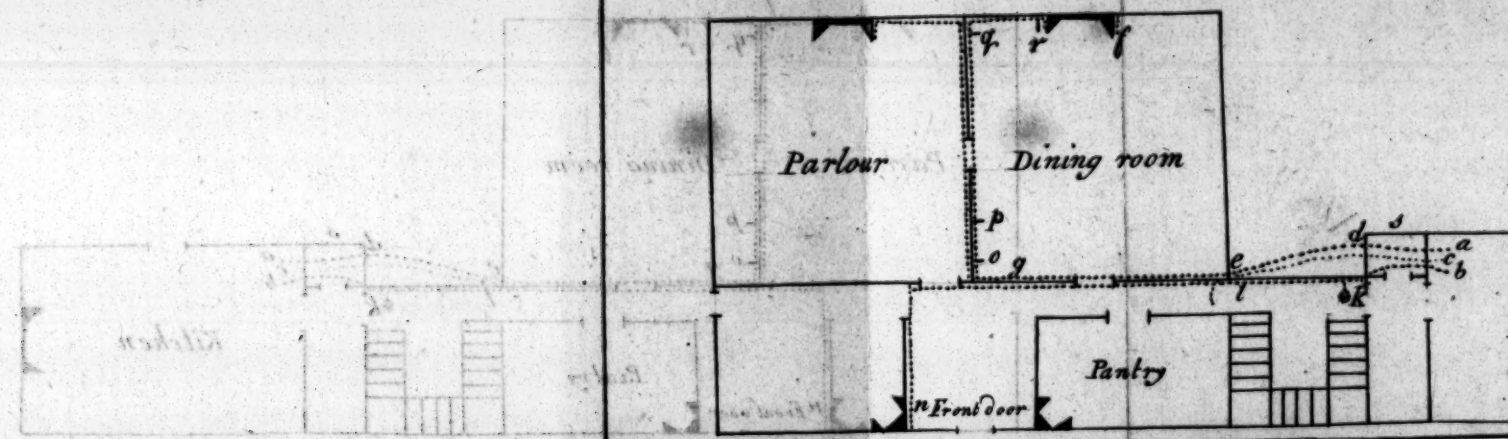


Fig. II



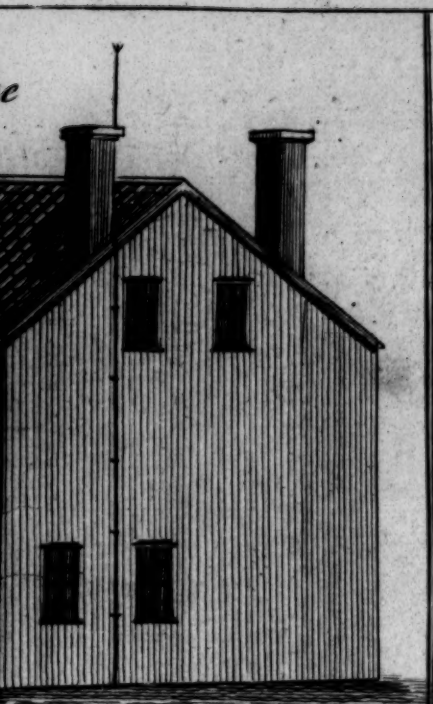


Plate 3

Facing p. 256

Rock raised up 3 inc.

Rock passed round

Rock passed over

Fig. III

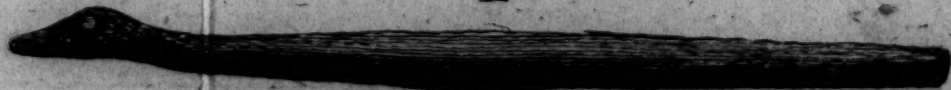
Stone thrown 4 rods
of 20th w.

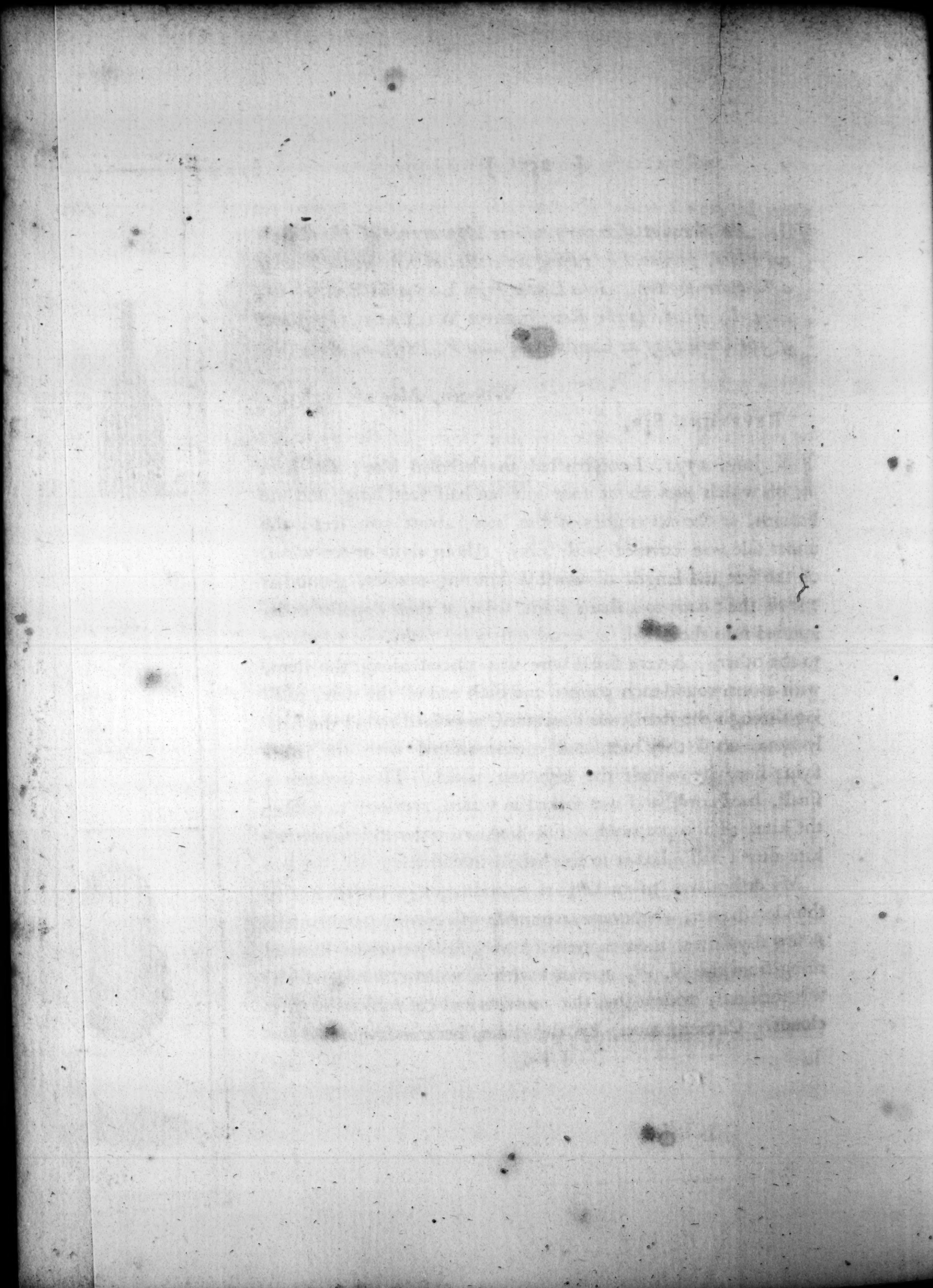


Kitchen

- 1 The place struck
- 2 The cracks in the rock
- 3 The main branch
- 4 The second main branch
- 5 The third main branch

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VII. *An Account of a very curious Appearance of the electrical Fluid, produced by raising an electrical Kite in the Time of a Thunder-shower. In a Letter from LOAMMI BALDWIN, Esq; F. A. A. to the Rev. JOSEPH WILLARD, President of the University at Cambridge, and V. Pres. A. A.*

Woburn, May 26, 1783.

REVEREND SIR,

IN July, 1771, I constructed an electrical kite; the stem of which was about four and an half feet long, and the breadth, at the extremities of the bow, about two feet: the under side was covered with silk. About eight or ten wires, of the size and length of worsted knitting-needles, ground at one of their ends to a sharp point, were, at their opposite ends, inserted into the stem, at equal distances, from one extremity to the other. A very small wire was placed along the stem, with a turn round each point: and each end of the wire, passing through the stem, was continued, entwined round the belly-band, until they met, and communicated with the main flying line, by which the kite was raised. This line was a small, hard cord, and was soaked in water, previous to raising the kite. I also prepared a silk line, in order to insulate the kite after I had raised it to the height intended.

My design was to make some experiments in the time of a thunder-shower, whenever a favourable opportunity should offer. A few days after, there appeared a very heavy thunder-shower rising from the N. W. attended with a violent wind, which was then only evident by the motions and convulsions of the clouds. Circumstances, by this time, became favourable for

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my designs, although it was yet calm where I was. I made ready my apparatus ; and the wind freshened up, and presently blew a considerably hard gale. The highest verge of the rising cloud was not yet elevated more than to the fifty-fifth or sixtieth degree from the horizon, but attended with the most piercing shafts of lightning, and tremendous thunder that I had ever beheld or heard, at the same distance,—and the zenith still serene. I adjusted the lines of the kite as near as I could to the strength and power of the wind, and soon raised it to the height of some lofty trees, which stood near my house, or perhaps something higher, but I am sure not much. By this time I discovered a rare medium of fire between my eyes and the kite.—I cast my eyes towards the ground ;—the same appearance was there.—I turned myself around ;—the same appearance still between me and every object I cast my eyes upon.—I felt myself somewhat alarmed at the appearance. I stood, however, and reasoned with myself upon the cause, for some time, but gained very little satisfaction,—the same fiery atmosphere surrounded me, only more bright and apparent. I was about to discontinue my experiments for that time ; but reason accused imagination with error ; and supposing it might possibly be only fancy, not knowing the cause of such an appearance, and feeling no very bad effects from it, I continued to raise the kite. The cloud had not yet quite obscured the heavens over me, but appeared still to be very highly, though unequally, charged with the electrical fluid ; which, by gaining an equilibrium, caused an incessant rattling, as if the heavens were rending asunder. All this time, the fiery atmosphere was increasing and extending itself, with some faint gentle flashings ; but with no other effects upon me than a general weakness in my joints and limbs, and a kind of
of

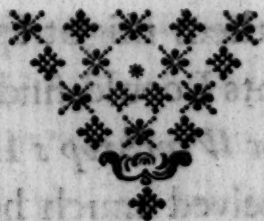
of listless feeling : all which might possibly be only the effect of surprise :—however, it was sufficient to discourage me from any further attempts at that time. I drew in the kite, and retired into a shop, which stood near my house, and continued there until the shower (which was ~~very~~ very severe) was over, and then went into my house, where I found my parents and family vastly more surprised than I had been myself ; who, after expressing their astonishment, informed me, that I appeared to them (during the time I was raising the kite) to be in the midst of a large bright flame of fire, attended with flashings ; and expected, every moment, to see me fall a sacrifice to the flame. The same was observed by some of my neighbours, who lived near the place where I stood.

I shall make no remarks, at this time, upon the cause ; but leave it for the present to the consideration of the learned.

I am, Sir, &c.

LOAMMI BALDWIN.

*The Rev. President Willard, Corresponding-
Secretary of the American Academy of
Arts and Sciences.*



VIII. *Observations and Conjectures on the Earthquakes of New-England.* By Professor WILLIAMS, F. A. A.

IN looking over some of the histories of *New-England*, I observed, that the religious turn of mind which distinguished the first planters of *New-England*, had lead them to take notice of all the Earthquakes which happened in the country, after their arrival. Several of them seemed to be pretty well described ; and in some of their phenomena, there seemed to be an agreement. As several of these accounts were contained in writings but little known, I thought it might be of some service to philosophy, if a particular account of them could be collected. This is what I have attempted in the following treatise. In the *first part* of it, I have set down the most particular accounts I could find of their phenomena. The *second* contains observations and remarks upon their agreement and operations. In the *third*, conjectures are proposed as to their causes : and in the *fourth*, some general reflections are added as to their nature, use, and effects.

The most likely way to come to the knowledge of their causes, is to observe all the phenomena that attend them. That the reader might have a true account of these phenomena, it was my endeavour, in the accounts and observations, to note all the particulars that seemed to relate to them, however minute or trivial some of them might appear. With this view, I consulted all the accounts I could find. From several of them, (the Honourable Professor *Winthrop's* Lectures on Earthquakes, in particular) I have received much help. Others referred to authors of which I could not have the advantage of a perusal. That gentlemen of science might have it in their power to examine

amine with what fidelity and care the accounts are drawn up, or how far they might be depended upon, I have constantly referred to the authors from which they are taken. Some of the accounts, I am sensible, are greatly imperfect : as all our conjectures, theories, and reasonings, must depend on the accounts, it is much to be wished, that something more accurate and perfect, as to several of them, might be transmitted down to posterity.

What is proposed as to their *causes*, will be judged of, by the degree of probability and evidence with which it is attended. In all philosophical hypotheses, a writer is in danger of making more of his subject than will bear a strict examination. I have found some difficulty in guarding against this : and whether, at last, I have not carried *conjectures*, in some things, too far, the reader must judge for himself. After all, the revolutions of time will afford the surest proof of the truth or errors contained in the following pages. I would, therefore, make it my request to posterity, to note, with care and accuracy, the phenomena that may attend any future earthquakes in *New-England*; that, if what is here advanced as to their causes, shall be found to be true, it may be confirmed ; but, if found to be false, it may meet with the fate of other errors, and be rejected. The cause of truth and science, is of infinitely more importance, than any of our schemes or conjectures : and this is what I wish may prevail, in all countries, and in all ages.

An

AN HISTORICAL ACCOUNT of the EARTHQUAKES
of NEW-ENGLAND.

THE *English* arrived at *Plimouth*, in *New-England*, November 11, 1628. The *first* earthquake that happened in the country after their arrival, was on July 2, 1638, O. S. The *manner* of its approach, and the *violence* to which it arose, are pretty well described in accounts which are yet existing. It is described as having been preceded with a rumbling noise, or low murmur, like remote thunder. As the noise approached, the earth began to quake, till the shock arose to such a violence, as to throw down the pewter from the shelves, stone walls, and the tops of several chimnies; and, in some places, made it difficult for people to avoid falling. The *course* of this earthquake, in some of the accounts, is described as being from the westward to the eastward. In others, it is represented as coming from the northward, and going off southward. It is not likely any great care, or accuracy, was employed, to determine what particular point of the compass the roar or shake came from; but only to fix it to that, which was judged to be the nearest cardinal point, which some thought was the west, others the north. It is most probable, therefore, that a middle course, from about north-west to south-east, was the true; as this will best agree with, and reconcile all the other accounts that were given of its course. To what *extent* this earthquake reached, on any point of the compass, we have no way to determine.— It is said in general, that it reached far into the land, and was observed by the *Indians* much beyond any of the *English* settlements, which then were but of small extent. And also, that some vessels, which were near the coast, were shaken by it. In

In about half an hour there was another shock, but not so long or strong as the former.*

Omitting a shock on October 29, 1653, as too small to occasion a general notice, the next memorable earthquake, was in 1658. In all the ancient histories, this is mentioned as a *great* earthquake. But I cannot find any account of the month, day, violence, course, effects, extent, or any other particulars of it.

On January 26, 1663, O. S. "at the shutting in of the evening,"† another memorable earthquake shook *New-England*. From the general expressions the writers who speak of it use, it seems to have been one of the *greatest* this country ever felt. It is represented as being preceded with a great noise and roar. Mention is made of the houses rocking, the pewter falling from the shelves, the tops of several chimnies falling in, the inhabitants running out into the streets, passengers being unable to keep on their feet, &c. As to its *course*, *duration*, or *extent*, nothing is to be found in any of the *New-England* writers. But they are well described in the accounts that were given of this earthquake in *Canada*.

At the same time, February 5, 1663, N. S. "about half an hour after five in the evening," a most terrible earthquake began there. The heavens being very serene, there was suddenly heard a roar, like that of a great fire. Immediately the buildings were shaken with amazing violence. The doors opened and shut of themselves, with a fearful clattering. The bells rang, without being touched. The walls split asunder. The floors separated, and fell down. The fields put on the appearance of precipices,

* Vide *Johnson's*, *Hubbard's*, and *Morton's* accounts of this earthquake.

† *Morton*.

precipices ; and the mountains seemed to be moving out of their places : and amidst the universal crash which took place, most kinds of animals sent forth fearful cries and howlings.

The *duration* of this earthquake was very uncommon. The first shock continued half an hour before it was over ; but it began to abate in about a quarter of an hour after it first began. The same day, about eight o'clock in the evening, there was a second shock, equally violent as the first ; and in the space of half an hour, there were two others. The next day, about three hours from the morning, there was a violent shock, which lasted a long time : and the next night, some counted thirty-two shocks ; of which, many were violent.—Nor did these earthquakes cease until the July following.

New-England and *New-York* were shaken with no less violence than the *French* country. And, throughout an *extent* of three hundred leagues from east to west, and more than one hundred and fifty from north to south, the earth, the rivers, and the banks of the sea, were shaken with the same violence. The shocks sometimes came on suddenly ; at other times by degrees. Some seemed to be directed upwards ; others were attended with an undulatory motion.—And throughout the vast extent of country to which they reached, they seemed to resemble the motions of an intermitting pulse, with irregular returns ; and which commenced through the whole at the same hour.

This earthquake was attended with some remarkable *effects*. Many fountains and small rivers were dried up. In others, the water became sulphureous : and in some, the channel in which they ran before, was so altered that it could not be distinguished. Many trees were torn up, and thrown to a considerable distance.

And

And some mountains appeared to be much broken and moved. Half way between *Tadoussac* and *Quebec*, two mountains were shaken down : and the earth thus thrown down, formed a point of land, which extended half a quarter of a league into the river *St. Lawrence*. The island *Aux Coudres*, became larger than it was before : and the channel in the river, became much altered.*

From these accounts it is evident, that *Canada* was the chief seat of these concussions : and of consequence, as it proceeded from those parts, its *course* must have been from some point between the west and north ; probably much the same with that of 1638.

After an interval of sixty-four years, (in which there had been several small shocks, but none so violent as to occasion a very long remembrance†) there came on another very memorable one, October 29, 1727, O. S. About 10^h 40', P. M. in a very clear air and serene sky, when every thing seemed to be in a most perfect calm and tranquility, a heavy rumbling noise was heard. At first it seemed to be at a distance, but increased as it came near, till it was thought equal to the roar of a blazing chimney, and at last to the rattling of carriages, driving fiercely on pavements. In about half a minute from the time the report was first heard, the earthquake came on. It

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* Vide *Frenier's Voyage*, p. 210, 211. *Journal des Savans Mai. 1678.* *Charlevoix's Histoire de la Nouvelle France.*

† In *Phil. Trans.* No. 437, mention is made of earthquakes in 1660, 1665, 1668 and 1669. Dr. *Mather* speaks of earthquakes in 1670 and in 1705. There was another in 1720, on January 8. But these, with some others, having been too small to occasion a general notice, and being only mentioned without any particular account of them, are passed by, as not affording us any light with regard to the nature, cause, or effects of these phenomena.

was observed by those that were abroad, that as the shake passed under them, the surface of the earth sensibly rose up, and then sunk down again ; which must have produced an *undulation* of the earth, or a motion like that of a wave, both perpendicular and horizontal ; first rising in a perpendicular direction, and as it subsided, spreading itself in a horizontal direction all around. The nature, therefore, or *kind* of the *motion*, was *undulatory*. The *violence* of the shock, like that of the other great earthquakes, was such as to cause the houses to shake and rock, as if they were falling to pieces. The doors, windows, and movables, made a fearful clattering. The pewter and china were thrown from their shelves. Stone walls, and the tops of several chimnies were shaken down. In some places, the doors were unlatched and burst open, and people in great danger of falling. There were various opinions as to the *duration* of this earthquake. The most probable is, that the shake began about half a minute after the roar was first heard, and rose to its greatest height in about a minute more ; and was about half a minute in going off. Whence, the *duration* may be supposed to have been about two minutes. It was very generally agreed, that the *course* of this earthquake was from north-west to south-east. " The noise and shakes, it is said, seemed to come from the " north-westward, and to go off south-easterly ; and so the " houses seemed to reel." This account of its course, was confirmed by all the others, one or two excepted, which differ so much from one another, that nothing can be determined from them. With regard to the *limits* of this earthquake, it extended from the river *Delaware*, in *Pennsylvania*, south-west, to *Kennebeck*, north-east. At both these places it was sensibly felt, though the shake was but small. Its extent, therefore,

from

from south-west to north-east, must at least have been seven hundred miles, and probably many more. As to its other limit, from north-west to south-east, we have no way to determine how far it extended. It was felt by vessels at sea, and in the most remote westerly settlements. As it came from the unknown parts, between the west and north, and passed off into the sea, it is probable it might run some thousand miles in such a course.

There were several *effects* attending this earthquake, which seem worthy of remark. Besides what is common, as to the throwing down pewter, fences, &c. it was observed, that several springs of water, and wells, that were never known to be dry or frozen, were sunk far down into the earth. Some were dried up. The quality of the water mended in some, and so altered in others as to freeze in moderate weather. Some spots of firm dry soil, became perfect quagmires; and others, that were full of mire and water before, became more dry. The centre of this earthquake, or place of greatest violence, seems to have been at *Newbury*, a town which lies at the mouth of *Merrimack-River*. "There, (according to Dr. Colman's account) "the earth opened, and threw up several loads of a fine "sand and ashes, mixt with some small remains of sulphur; "so that, taking up some of it between the fingers, and dropping it into a chaffing-dish of bright coals, in a dark place, "once in three times the blue flame of the sulphur would "plainly arise, and yield a very small scent. By this it seems "evident, that it was a sulphureous blast which burst open the "ground, and threw up the calcined bituminous earth."*

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* Phil. Transf. No. 409. What is here said of its being a sulphureous blast, seems to be confirmed by the account which Mr. Dudley sent to the Royal Society, in which

cerning this earth which was thrown up, the Rev. Mr. *Lowel*, minister in *Newbury*, mentions an uncommon circumstance.

“ One thing (says he) I may add, which is very remarkable,
 “ and which may be depended on : that about the middle of
 “ April, that fine sand, which was thrown up in several places
 “ in this parish, at the first great shock, October 29, had a very
 “ offensive stench ; nay, was more nauseous than a putrifying
 “ corps ; yet, in a very little while after it had no smell at all.
 “ How long it was before it begun to have this stench I am
 “ not certain. I know it had it not at first : and, I believe, it
 “ was covered with snow till a little while before.—There is no
 “ smell now.”*

These accounts refer to matters so easy to be known, that there is no room to suspect that the authors (both gentlemen of a philosophic taste, as well as of eminence in their particular professions) could be mistaken. And it seems highly probable, from their observations, that the sand which was thrown out by the earthquake, contained some very noxious, ill-scented vapour, or effluvia ; which, so long as there was nothing to confine it, passed away in quantities too small to be perceptible to the senses : but when it was kept together by the snow, gathered in such quantities as strongly to infect the air, when the melting of the snow gave it liberty to evaporate freely.

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which he says, “ A clergyman in a town about twenty miles from *Boston* assured him, that immediately after the earthquake, there was such a stink, or strong smell of sulphur, that the family could scarce bear to be in the house for a considerable time that night. The like is also confirmed from other places. Persons of credit do also affirm, that just before, or in the time of the earthquake, they perceived flashes of light.” Phil. Trans. No. 437.

* Letter to Dr. Colman. Phil. Trans. No. 409.

Some phenomena were observed a few days before this earthquake, which deserve our notice, as having, probably, some connection with its approach. The Rev. Mr. *Allin*, then minister of *Brooklyn*, took notice of an uncommon alteration in the water of some wells. "About three days (says he) before the earthquake, there was perceived, an ill-smelling smell in the water of several wells. Not thinking of the proper cause, some searched their wells, but found nothing that might thus infect them. The scent was so strong and offensive, that for about eight or ten days they entirely omitted using it. In the deepest of these wells, which was about thirty-six feet, the water was turned to a brimstone colour, but had nothing of the smell; and was thick like *puddle-water*."§ We have this account confirmed by Mr. *Dudley*.—"A neighbour of his that had a well thirty-six feet deep, about three days before the earthquake, was surprised to find his water, that used to be very sweet and limpid, stink to that degree that they could make no use of it, nor scarce bear the house when it was brought in; and imagining that some carrion was got into the well, he searched the bottom, but found it clear and good, though the colour of the water was turned wheyish, or pale. In about seven days after the earthquake, the water began to mend; and in three days more, it returned to its former sweetness and colour."* And just before the earthquake began, several wells were found to have no water in them, which had great quantities before and after. To whatever cause the alterations in these wells be ascribed, it can hardly be thought but that they had some connection with the earthquake, which

§ Account of the earthquake of 1727, by Mr. *Allin*.

* Phil. Trans. No. 437.

in a few days ran through the whole country. Several shocks were felt in the northern parts of *New-England*, for some months after that of October 29 : but they were generally small and of a short duration.*

In 1732, there was an earthquake, which, though small, was of a considerable extent. It came on September 5, O. S. at about 11^h. A. M. being attended with a rumbling noise ; and was of such *violence* as to occasion a considerable jarring of the houses. The *duration* of it, was not more than ten or fifteen seconds. This earthquake was much more evident at *Montreal* in *Canada*, than it was in any part of *New-England* ; being attended with considerable damage there. As this was the chief seat of it, it seems to have come from thence, in a *north-westerly course*, to *New-England*. Its *extent*, from south-west to north-east, was equal to that of most of the earthquakes that have been in the country ; being felt from *Maryland* to the *northeasterly* parts of *New-England* : and from north-west to south-east, it reached from *Montreal*, and probably from many miles beyond it, to the sea-coast.||

From the year 1732, though there had been some small shocks, there was none that occasioned a general notice, till 1744. That year, on June 3, O. S. a fair and hot day, there was an earthquake, so considerable, as to be generally felt thro' the province. It began a few minutes after 10^h. A. M. being preceded

* The account of this earthquake is collected from the printed accounts of it in the *Philosophical Transactions*, and by several of the *New-England* ministers.

|| Vide *Phil. Transf.* No. 429, and for 1757, p. 13, and also Professor *Kalm's* travels, vol. i. p. 44, 2d edit. *London*. On February 6, 1737, at 4^h P. M. and December 7, a little before eleven at night, small earthquakes were felt at *Boston* : but no particulars are mentioned as to their phenomena.

preceded with a very loud report ; and is said to have rose to such a *violence*, as to shake down some bricks from the tops of some chimnies, and also some pieces of stone wall. The *course* of this earthquake is said, by some that remember it, to have been from the *westward* to the *eastward*. As to other particulars I can find no account.†

The next earthquake, that shook the whole country, was in the year 1755. November 18, N. S. at 4^h 11' 35",‡ in a calm, serene and pleasant night, came on the most violent shock of an earthquake that was ever known in *New-England*. The first thing observable, was that rumbling noise, or roar, which as a sound *sui generis*, seemed a prelude to an earthquake. In about half a minute, the surface of the earth seemed to be suddenly raised up ; and, in subsiding, was thrown into a universal trembling, or a very quick, jarring, vibratory motion, which acted in an horizontal direction. This motion continued for about a quarter of a minute, and then abated for three or four seconds. Then, all at once, came on a violent, prodigious shock, as suddenly, to appearance, as a thunder-clap breaking upon

† Phil. Trans. for 1757, p. 14, and *American Mag.* for 1744.

‡ The beginning of this earthquake was determined to all the exactness that could be desired, by the following accident.—Professor *Winthrop* at *Cambridge*, some time before, having used a pretty long glass tube, in a particular experiment, shut it up in his clock-case, for security. This tube, standing nearly perpendicular, must have been overfet by the first shock, which made it impossible for the pendulum to make any oscillation, after the tube had struck against it. The clock stopped at the time mentioned above. Being a very good one, and having been adjusted by a meridian line, the preceding noon, it must have pointed out the beginning of the earthquake to a great precision. Had the time been as accurately determined at any other distant place, the velocity of its motion might have been determined to great exactness.

upon a house, and attended with a great noise. This sudden and great shock began with the same kind of motion; and was immediately succeeded by quick and violent concussions, jerks and wrenches, attended "with an undulatory, waving motion of the whole surface of the ground, not unlike the shaking and quaking of a very large bog." After this great shock had been gradually declining and going off, near half a minute, there was a sensible revival of it, though of short continuance; and so all by degrees became still and quiet again.

The violence of this earthquake was the greatest of any we have ever had in the country. "In Boston, besides the throwing down of glass, pewter, and other movables in the houses, about an hundred chimnies were, in a manner, levelled with the roofs of the houses; and about fifteen hundred shattered, and thrown down in part. Some were broken off several feet below the top; and by the suddenness and violence of the jerks, canted horizontally an inch or two over, so as to stand very dangerously. Some others, thus broken off, were turned round several points of the compass, as with a circular motion. The roofs of some houses were quite broken in by the fall of chimnies. The ends of about twelve or fifteen brick buildings were thrown down, from the top to the eaves of the houses. Many clocks were stopped. The vane upon the public market-house was thrown down;—the wooden spindle, which supported it, being broken off at a place where it was five inches in diameter, and ten feet in height; and which had stood the most violent gusts of wind. A new vane, upon one of the churches in the town, was bent at the spindle, two or three points of the compass: and a distiller's cistern, made of plank, almost new, and very strongly put together, was burst to pieces, by the agitation of the

the liquor in it; which was thrown out with such force, as to break down one whole side of the shed that defended the cistern from the weather; as also to stave off a board or two from a fence, at the distance of eight or ten feet from it." Much the same things were observed in the country. At *Springfield*, a town distant about eighty miles in a westerly line from *Boston*, a spindle on one of their churches, was bent to a right-angle.—And through the whole province, much damage was done by the throwing down of stone fences, cellar walls, chimnies, and the like. These things may serve to give us pretty just ideas of its violence: but it is to be observed, that the violence of the shock was different in different places; and not exactly the same in towns contiguous to one another; or indeed in all the parts of the same town.

There has been no earthquake in the country, whose duration was determined with so much accuracy as was that of this. Professor *Wintthrop* at *Cambridge*, the day before, had adjusted his clock and watch by a meridian line. His clock was stopped at 4^h 11' 35". Being awaked by the earthquake, he arose, and looking upon his watch, found it to be fifteen-minutes after four. The jarring continued about a minute after this. The next day the watch was found to have kept time very exactly. So that the duration of the earthquake, taking in the whole of the time from the first agitation of the earth, till it became perfectly quiet, was very nearly four and an half minutes; though the violence of the shock did not last half so long. This observation of its duration at *Cambridge*, agreed pretty well with some of the same kind made at *Boston*, by gentlemen who were up, and looked upon their watches when it began and ended.

In other places, its duration might be different, according to the different violence of the shock.

By the accounts of those who were in the commons and open places, when the earthquake began, the *course* of it was nearly from north-west to south-east. It was almost universally agreed, that the noise and shakes seemed to pass in that direction : and those things which were in such a situation as that they might have been thrown indifferently to any point of the compass, pretty generally lay in that direction.

The *extent* of this earthquake, was traced to a great distance. On the south-west, it reached as far as *Chesapeake-Bay* in *Maryland* : being felt on the eastern, but not on the western side. To the north-east, it was felt as far as *Halifax*. It is much more difficult to determine its western or eastern limit.—It extended to all our back settlements ;—was felt at *Lake George*, and probably many miles beyond : but at *Oswego*, situate on the south-eastern shore of *Lake Ontario*, and distant from *Boston* about two hundred and fifty miles west-by-north, it was not felt at all. On the *Atlantic*, the shock was so great seventy leagues east of *Cape Ann*, that the people on board a vessel, in that longitude, thought they had run aground, or struck upon a rock, till on sounding they found they had more than fifty fathom water : By accounts, which were soon after received from the *West-Indies*, it seems probable that the earthquake reached as far as those islands ; or, rather, passed by to the eastward of them. The account was, “ That on the 18th of November, “ about two o’clock in the afternoon, the sea withdrew from “ the harbour of *St. Martin’s*, leaving the vessels dry, and fish “ on the banks, where there used to be three or four fathom “ water : and it continued out a considerable time ; so that the “ people

“ people retired to the high lands, fearing the consequence of
 “ its return : and when it came in, it arose six feet higher than
 “ usual, so as to overflow the low lands. There was no shock
 “ felt at the above time.”

As this extraordinary motion of the sea happened about nine hours after the great shock was felt in *New-England*, it seems very likely to have been occasioned by the same convulsion of the earth. As this earthquake went off south-eastward into the *Atlantic*, it would pass considerably to the eastward of *St. Martin's*, which has about 18° of north latitude, with $62\frac{1}{2}^{\circ}$ of west longitude. And this was the case at the island. There was no shock felt ; but the motion of the sea was probably owing to a great agitation, raised at a considerable distance, in some part of the ocean, by the passage, or by an eruption of the earthquake, and from thence propagated to that island.— And what seems to be a confirmation of this, the length of time was no greater than what seems necessary for such a purpose. We cannot, indeed, state, with great accuracy, the velocity with which the earthquake moved : but yet it is very evident from its duration, and being preceded with a roar, that its motion was not very swift : and that of the waves, raised hereby, and propagated to the land, must have been much slower : both of which might easily take up nine hours in being propagated, and that in a circular direction, to such a distance as that of *Boston* and *St. Martin's*. The extent, therefore, of this earthquake, from south-west to north-east, must have been about eight hundred miles : but from north-west to south-east, it reached at least nineteen hundred ; and, perhaps, many more.

As the *effects* of this earthquake, great alterations were observed in the springs, wells and ponds of water. In some, the quality of the water was altered; in others, the quantity. New springs were opened; old ones dried up: the channel in many, was much changed; and the water in some was observed to boil up in an unusual manner, for several days both before and after the earthquake. At *Pembroke, Scituate and Lancaster*, there were chasms made in the earth. At *Pembroke*, there were four or five of them; out of some of which, water issued, and many cart-loads of a fine, whitish and compressible sort of sand, was spewed.* Nor were its effects confined to the land;—several of the sea-faring men agreed in their accounts, that almost immediately after the earthquake, large numbers of fish, of different sorts, both great and small, came up to the surface of the water,—some dead, and others dying. One of the fishing vessels, at that time out upon the *Banks*, took up and brought in several quintals of these fish, which were found in large numbers, dead and dying, upon the surface of the sea.†

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* Speaking of this sand, "By what I have heard," says Dr. *Mayhew*, "it was of a sulphureous nature." It is to be regretted, that no experiments were made with it, to determine, with certainty, whether this was the case or not.

† In phenomena, of whose causes we have so little knowledge, it is best to note every circumstance however minute, and whether it seems to have much connection with the supposed causes or not; as we do not know but that they may be of use, when future observations come to be compared with them. For this reason, it may not be amiss to subjoin to the above account, 1. That at the time of the earthquake, there was no alteration in the atmosphere, as to its weight or temperature: the *barometer* and *thermometer* not undergoing any alteration. 2. A very great white frost was observed in the morning, much larger than had been for several years. When it was melted, Professor *Winthrop* measured it, and found that it covered the ground

There were several small shocks soon after this of November 18.—One in about an hour and a quarter after the first, viz. at 5^h 29'. A second, on November 22, at twenty-seven minutes after eight at night. A third, on December 19, at 10^h P. M. Their violence and duration was small; their course, much like that of the great shock; and their extent, such as to be pretty generally felt through the country. Many others, but very small, were felt in different parts of the *Massachusetts* and *New-Hampshire*, for several months after.

In 1757, there was another earthquake; which, tho' small, was generally felt. I cannot find any printed account of this shock, and, therefore, can only mention some general observations, which I then made of it. It came on July 8, N. S. at about 2^h 20', P. M. I was then in an open field, surrounded with pretty high hills, from south-west to north-east, in company with another person. The first thing we perceived, was a small noise, like that of a rising wind, which seemed to be at a great distance, but swiftly advancing. It was half a minute before there was any shock. This I inferred, not barely from any conjecture I was then able to make, which in a state of surprise must be greatly uncertain, but from this circumstance: after hearing the noise, we had enquired of each other what it could be; and as there was no shake, concluded it was not an earthquake, when immediately the shock came on. The conversation I well remember; and am certain it must have taken up half a minute, if not more. The shock itself was not of very great ground, ^{1/1000} parts of an inch; which was almost double of any there had been for seven years before, and about five or six times as great as what is common in this country. The account of this earthquake is collected from Professor *Winthrop's* Lecture, and account of it in *Phil. Trans.* for 1757, art. 1. and from Drs. *Chauncy's* and *Mayhew's* accounts of it.

great force ; but seemed as though some small body was swiftly rolling along under the earth, which gently raised up that part of the surface that was over it, and then left it as gently to subside. The *course* of this earthquake appeared, to me, to be from the south-west to the north-east. The noise and shake seemed very plainly to come on, and go off in that direction. I might, however, be deceived by the reflection of the sound from the adjacent hills, or from some other cause ; for almost every one judged very differently of its *course*, that it was from north-west to south-east. This was the judgment of several men, who were at work together, in a large open field, where there was nothing to reflect the sound, or mislead the judgment. It is not impossible that both might have been right in their opinion ; and this, upon the whole, I am apt to think was the case : that although its general *course* was from north-west to south-east, yet, in particular places, it left its general *course*, and run out to any point of the compass, as the subterraneous veins, or channels, might lead it. From the effects of other earthquakes, particularly that of turning and twisting chimnies, &c. it seems as though this had been the case with most of the large earthquakes we have had.

On the 12th of March, 1761, there was also a small earthquake. It began about 2^h 30' in the morning. It was said to have been divided into two shocks, with a small pause between, the last of which was the greatest. The weather was moderate, like that of the preceding day, and a perfect calm rested on the land and water ; the horizon, all around, being covered with a whitish fog. The *duration* was supposed to be about half a minute. Happening in the night, and being too small to awake people in general, nothing can be collected with any certainty

as to its *course*. Its *extent*, however, was considerable ; being felt not only in the *Massachusetts*, but in most of the adjoining states.

The same year, on November 1, about 8^h. P. M. there was another earthquake. As usual, this was preceded with a heavy rumbling noise, which increased to a pretty loud report as it came near. There was a considerable interval of time between the roar and the shake. I endeavoured to make some computation of it by this method : just as the shock began to abate, I looked on my watch to note the time. The report I could hear for about half a minute after this. It is probable it was about as long in coming on, which would give half a minute between the noise and shake. The *shock* itself was of the *undulatory* kind ; not *violent*, but sufficient to make the doors and windows jarr and clatter. Its *course* was very plainly from north-west to south-east, and it was pretty generally felt through the state, and in *New-Hampshire*.

In the years 1766, 1769, and 1771, there were small earthquakes. Their *courses* were all, I think, from about north-west to south-east. Their *durations* not more than twelve or fifteen seconds ; and their *extent* but small. Not being attended with any thing remarkable, it is not necessary to write particular accounts of them.

November 29, 1783, about 10^h. 54', P. M. there was another small earthquake in *New-England*. Its *extent* was very considerable ; being felt in *Pennsylvania*, *New-Jersey*, *New-York*, *Connecticut*, *Rhode-Island*, *Massachusetts* and *New-Hampshire*. At *Boston*, there was but one shock ; and that was not violent enough to be generally perceived. At *Hartford* and *New-Haven*, in *Connecticut*, but one shock was perceived ; but

it seems to have been more considerable than at *Boston*. At *New-York*, three shocks were felt, about the hours of nine, eleven, and two the next morning. At *Philadelphia*, they had a shock about eleven o'clock, and another the next morning, about two. At the first of these, "most of the houses were very sensibly shaken," but the other was not generally felt. Being but small in most places, and happening in the night, the *course* of this earthquake was not much attended to. The only remark I can find upon this, is in an account from *New-Haven*; in which it is said, "Its *course* was nearly from north to south, and it continued about one minute."

OBSERVATIONS and REMARKS on the EARTHQUAKES of NEW-ENGLAND.

TO have a general view of the agreement and disagreement of the phenomena that have attended the earthquakes of *New-England*, it may be of use to make some general observations on the preceding HISTORICAL ACCOUNT.

It seems worthy of remark, that all the earthquakes of this country, have been of the same *kind*. Writers on this subject, have sometimes distinguished earthquakes into two different kinds, according to the different *motions* of which they have consisted.—In some, an *horizontal*, in others, a *perpendicular* motion has been chiefly observed. In the one, the earth seemed to move, as it were, from side to side: in the other, its motion seemed to be up and down. Both these motions have been united in the earthquakes of *New-England*. All, of which we have had any particular account, have come on with
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an *undulatory* motion, like that of a wave; which first rises till it comes to its greatest height, and then subsides; and in subsiding, spreads itself, with an horizontal motion, all around. This has appeared, with the most sensible evidence, to be the case, in all the earthquakes I have ever felt. They have all appeared, to me, to come on, as if a solid body, or a wave of earth, (if the expression may be allowed) was rolling along under the surface of the earth; which first raised that part which was over it, and then left it gradually to subside: the consequence of which was, a strong *undulatory motion* of the earth; which was immediately succeeded with an universal trembling, or very quick, jarring, vibratory motion, as though the earth was struggling to recover its former position.

Another thing observable in the earthquakes of *New-England* is, they have all gone in much the same *course*. As to two or three of the earthquakes, we have no account of their *course*: but in all those in which it was determined, there is a very great agreement. They are all described as coming from about north-west, and going off about south-east. As this was the case with all whose direction was observed, we may rationally conclude, that they all proceeded in pretty much the same general track; in a path from about north-west to south-east, though with many small deviations and irregularities, in particular places. This, if I do not mistake, has not been generally the case in the earthquakes of other places. The great earthquakes which have spread desolation in *Sicily*, *Peru*, and *Jamaica*, instead of proceeding in any regular course, are described rather as instantaneous blasts, which struck dreadfully upwards,—not proceeding in any certain tract, from one country to another; but such as burst and rent a large circle of earth

all around. But with us, they have all proceeded in a different manner ; and in a manner apparently regular ;—fiercely driving along, as it were, in the same path, as though a passage had been opened for, or by them, from one country to another ; in some places coming more near, and in others, running more remote from the surface of the earth. And the distance to which some, and probably several have run in the same course, has been greatly amazing ;—nineteen hundred miles at least, and how much more we know not.

From the last remark it seems probable, that the earthquakes of this country, have had their *origin* at some considerable distance to the north-west of *New-England*, and possibly at much the same place. Whatever might be the case with those small shocks that have had but a small extent, or wheresoever they might begin, the larger ones have all been observed to come from the north-west ; and they were of much the same violence at the most north-westerly settlements, as at other places in the country. The place, therefore, where they have had their *origin*, must have been in some part of the unknown lands which lie to the north-west of *New-England* ; and probably at some considerable distance from any of the *European* settlements ; as there has been no account from any of them, in which it had not the same direction, coming on from the north-west. Whether the great shocks have all originated at the same place, we have no way to determine ; but from the agreement of their courses and motions, it seems not an improbable supposition.

There seems to have been a particular part of the continent of *North-America*, which has been the *seat* of the earthquakes of *New-England*, and to which they have always been confined.

To

To the south-west, they have several times reached as far as *Maryland*; but never so far as *Virginia* or *Carolina*. To the north-east, they have been bounded by *Nova-Scotia*; having never been felt much further than *Halifax*. From the unknown lands, at the north-west, they have gone off south-east, into the *Atlantic*: their extent this way, being greater than we are able to trace on either point of the compass. The province of *Massachusetts-Bay*, or rather, that part of *New-England* which is about the latitude of 43° north, where the river *Merrimack* empties itself into the *Atlantic*, has generally been the centre, or place of their greatest violence. If from this place, a line be drawn north-west, it will pretty well represent the central course of the earthquakes of this country: and from this line they have extended about four hundred miles to the south-west and north-east. It is not meant to be very particular, but only general, as to these boundaries.—And the whole country, within these limits, has been repeatedly shaken,—most violently about the middle, and least so towards the south-west and north-east boundaries. As far as can be gathered from the accounts, it seems probable, that most of the great shocks have reached to much the same places: the small ones, indeed, have not had such an extent; being felt only in different provinces and towns. But *all* the earthquakes, within the above-mentioned limits, have come from the same point, and ran in the same course: the great ones reaching to much the same extent, as though there was something to direct their motions the same way, and to confine them to the same limits.

With what *velocity* these earthquakes moved, it is not easy to determine. In many accounts of earthquakes, their motion has been said to be instantaneous, like that of the electrical shock.

shock. The reverse has been the case in the earthquakes of New-England. Instead of being instantaneous, their motion has never been very swift. To compute, indeed, with accuracy, with what velocity any of them moved, we have no sufficient *data*. Had the times at which any of them begun, been carefully noted at places whose distances were known, it might have opened the way to some very curious conclusions. But all the accounts, excepting one of Professor *Winthrop*, are too general to form any certain inferences of this kind. There is, however, one article in the accounts of the earthquakes of 1727, 1755, 1757 and 1761, from whence we may conclude, that the *velocity* of their motion, was considerably less than that of *sound*. Most of the accounts of the earthquakes of 1727 and 1755, agree, that the roar was heard at least half a minute before the shake began. The sound, therefore, that was occasioned by the approach of the earthquake, preceded the shock with a motion considerably swifter than that of the earthquake itself. Now, *sound* moves about thirteen miles in a minute; and the motion of this was considerably swifter than the motion of the earthquake. In the earthquakes of 1757 and 1761, the sound was also heard half a minute before the shock was felt: and as the report was much less, and therefore could not reach so far as in the larger shocks, the inference will be, that these small shocks moved with a velocity considerably less than the larger one. And, indeed, the supposition seems not improbable, that the *velocity* with which an earthquake moves, should bear some proportion to its *violence*,—to the strength and force of those causes, by whose operation it is produced. Whether there does not seem some evidence that this has been the case with us, the reader will judge for himself, from what
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has been observed above. If this is the case, as I believe it is, future observations may determine it with much more certainty and precision, than any that have yet been made.

But although we are able to discern some appearances of agreement and similitude in those phenomena that have been mentioned, we cannot discern any in the *times* in which these earthquakes have happened. From their having all proceeded in the same course, one might be led to suspect, whether their causes, whatever they are, operating in the same direction, would not require nearly the same intervals of time, to gather sufficient force to produce the same effects. But nothing of this nature is apparent. The intervals of time, at which they have happened, have been very different, and without any apparent regularity. Not to mention the smaller shocks, there have been five which have been distinguished by their being much larger than the rest: those, I mean, of 1638, 1658, 1663, 1727 and 1755. Between the two former of these, there was an interval of twenty-eight years.—Between the two next, an interval of five years: then one of sixty-four; and between the two last, of twenty years. At a medium, this will make one in about twenty-seven years. But in these different intervals, there is no apparent order, regularity, or proportion, in the times of their happening. Neither does there seem to be any proportion between *the intervals of time, and the violence of the shock*. One would be apt to imagine, that the longer the causes were gathering strength, the greater would be the violence of the earthquake when it came: and yet that of 1755 was greater than that of 1727, though the interval of time had not been half so long. It is to be observed, however, that as our accounts of the earthquakes are but imperfect, as to their number,

number, and much more so as to the degree of their violence, all our reasonings, upon this article, must be very uncertain.—Nor could we, without very accurate accounts of the time and violence of the earthquakes, the smaller ones as well as the greater, state any proportion between the *times* and the *shocks*, supposing such proportions to exist. But if there are any such proportions, or any order and regularity, in their periods, it is not apparent; but rather the contrary, from all the accounts I have been able to collect.

It is also worthy of remark, that these earthquakes do not seem to have any *connection* with any thing that falls under our observation. It has been suspected, by those who account for the origin of earthquakes on the principles of electricity, and by many others, that there is some connection between the state of the weather, or rather atmosphere, and the happening of an earthquake. As our knowledge of this subject is so imperfect, it may not be amiss to note every thing of this kind. And it is observable, that the earthquakes have generally happened in calm, serene and pleasant weather. Some of the accounts are very imperfect in this respect: but, in general, they seem to agree pretty much in this particular. But though it has generally been the case, that the earthquakes have come on in fair and pleasant weather, it has not been universally so.—In the earthquake which happened November 22, 1755, after the great shock on the 18th, the weather was not clear and fair, but dull, cloudy, and attended with small showers, and a brisk gale at south-west.—And in March, 1771, there was a small shock, when, instead of being fair weather, there was a heavy storm of snow. But perhaps it is of no great consequence to mention this. It has been more common for writers on this subject to attempt

attempt to find some *preceding signs*, or forerunners, of these events. And in this respect, fear and superstition have been abundantly fruitful. Philosophy has nothing to do with the many idle reports of this kind, that have prevailed among the vulgar. But among the many things that have been supposed to exist, there is one that deserves our notice, as having, probably, a real foundation in nature. Ancient and modern writers have supposed, that it might in some cases be a prelude to an earthquake, when the water, in deep pits, wells, caverns, springs, &c. is thrown into uncommon motions, disturbed, altered and changed, as to its course, kind, or quality. It is rational to suppose, that such events may, in some cases, proceed from those causes, which, in a little time, have burst out, and rent the adjacent country. Some curious observations of this kind, were mentioned by Messieurs *Dudley* and *Allin*, as happening a few days before the earthquake of 1727: and something of the same kind was observed previous to the earthquake of 1755. As these accounts have been mentioned,* it is unnecessary to repeat them here. I am far from supposing, that any certain prediction of earthquakes can be generally made from such observations; as such events may, and no doubt do happen, without being followed by any shocks; and earthquakes often take place without any such events. But at the same time, it can hardly be doubted but that the alterations observed in the water of these wells, was owing to the operation of the same causes, that in a few days burst forth with such violence as to shake all *New-England*. With regard to the ill effects that have succeeded earthquakes in some countries, it is well known there have been many and fearful accounts.

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* Vide p. 265 and 277.

In some places, they are said to have been followed with great mortality, pestilential disorders, and the most raging sickness. Nor is it improbable, that the air should be infected with noxious effluvia, from the vapours that were before confined, and perhaps corrupted. It seems credible, that something of this nature has been the case, and, probably, the consequence of earthquakes, in some places. Many of these reports, indeed, seem to be much like what has been said of the effects of comets, meteors, and the conjunctions of the planets.—But at the same time it seems probable, both from ancient and modern accounts, that in some places, pestilential disorders have, in fact, and probably as the consequence, succeeded great earthquakes. Nothing of this nature has been the case in *New-England*. It is, however, highly probable, from the Rev. Mr. *Lowel's* observation,* that some very noxious vapour, or effluvia, attended the eruption of the earthquake of 1727: but no bad effects, no pestilential distempers, no sweeping sickness, or uncommon disorder or mortality, has been observed to succeed any of the earthquakes of this country; no otherwise, at least, than what has been common at other times.

CONJECTURES on the CAUSES of these EARTHQUAKES.

IN this enquiry into the Causes of Earthquakes, it is not my design to enter into a particular discussion of the several hypotheses philosophers have assigned, as accounting for the production of such phenomena.—I mean to consider the subject

* Vide p. 268

ject no further than it has relation to the earthquakes of *New-England*, and what may be gathered, as to their causes, from the preceding HISTORY and REMARKS.

From the phenomena and observations that have been mentioned, we may safely infer, that the earthquakes of *New-England* have been produced by *something which has moved along under the surface of the earth*. Whatever may have been the case in other places, all the earthquakes of this country, so far as we have any accounts of them, have been of the same kind; consisting, not of a simple instantaneous vibration, like that of an electrical shock, but of a gradual heaving, swell, or undulation of the earth. This has moved along in much the same path, with a motion not very swift: and it has reached deep enough below the surface of the earth, to affect and disturb the fountains, springs, wells and pits of water. These phenomena, are effects, which would naturally lead us to conclude, that the causes, whatever they may be, had their seat, rise and operations under the surface of the earth. And this conclusion from the *phenomena*, is strongly confirmed from *observation*.—For the shocks have come on, rose to their greatest height, and gone off, to all appearance and observation, as if they had been occasioned by the rolling of some solid body under the surface of the earth. In this manner Professor *Winthrop* describes that which happened November 22, 1755:—
 “ I was then,” says he, “ sitting on a brick hearth: and the
 “ sensation excited in me, was exactly the same as if some small
 “ solid body, by moving along under the hearth, had raised
 “ up the bricks successively, which immediately settled down
 “ again.”* The same observation has been frequently made

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* Lecture on Earthquakes, p. 12.

by others ; and is agreeable to all the accounts that can be collected. And from these accounts of the several phenomena of the earthquakes, and the observations that have been made upon them, I think we may lay it down as *a pretty certain fact*, that the earthquakes of *New-England* have been caused by something which has moved along under the surface of the country.

What thus moved under, and hove up the surface of the earth, was probably *a strong elastic vapour*. This is inferred from the phenomena that have attended the earthquakes.

Among these phenomena, there were some that preceded the earthquakes, and looked like a *previous preparation*. In the earthquakes of 1727 and 1755, in particular, it was evident, that the causes by which they were produced, were at work several days before they became ripe for an explosion. As tho' some grand fermentation was taking place in the bowels of the earth, the water, in several wells and springs, was uncommonly altered in its motion, colour, smell and quality. This was observed three or four days before there was any earthquake. Nothing could better agree with the origin and production of a subterraneous elastic vapour, than this circumstance. For however such a vapour be generated, by mixture, fermentation or fire, it would require some previous preparation, for its production, or before it would be collected in sufficient quantities to cause an explosion, or acquire sufficient force to move and shake the surface of the earth.

The *noise* or *roar*, occasioned by the earthquakes, has always been such as might have been expected from a subterraneous vapour, when fiercely driving along under the surface of the earth. What report might be expected from a strong elastic vapour,

vapour, when its motion is confined and directed by a particular channel or passage, we may learn from that of a blazing chimney. The action of fire, when turning the inflammable materials, with which the chimney abounds, into flame and vapour, produceth a noise or roar of a very particular kind; and which seems to be different from almost any other: and there is nothing to which the report of our earthquakes is more similar, or has been more often compared.

There is also an apparent agreement between the effects of a subterraneous vapour, and the *kind* and *motion* of the shocks. When the materials, from which a subterraneous vapour is produced, lie promiscuously mingled and blended together, the effect of an explosion would be a violent ebullition, or blast upwards; tearing and rending a circle of earth, all around. This seems to have been the case in the earthquakes of *Sicily*, *Lima* and *Jamaica*. When the vapours can have a regular discharge through any aperture in the surface of the earth, they will vent themselves in copious effusions and exhalations, and thus spend their force this way, as they gather strength from time to time. Thus it has been with *Hecla* formerly; and with *Vesuvius*, *Ætna*, and other volcanoes now. But when the vapours are confined under the surface of the earth, and have subterraneous passages, or proper strata, for them to run in, by the violence of their expansion, they will heave up the surface of the earth, and thus cause, not an instantaneous concussion, but a progressive swell or undulation of the earth.— And this will be continued till the vapours, thus confined, find or force for themselves a passage, where they may burst from their caverns, and discharge themselves into the open air.—

And these are phenomena in all respects agreeing with those that have attended the earthquakes of this country.

The strength and force of such a vapour, would be sufficient to account for the *violence* of any shocks we have had. A very great force must be requisite to heave up, and cause a progressive swell in the surface of the earth, and this, perhaps, from some depth below.—And with what force subterraneous vapours may be attended, we may form some idea from their effects. In those which have shook *Vesuvius* and *Ætna*, it has been no uncommon thing to see them throw up at once, such clouds of sand, ashes and pumice-stones, as are capable of darkening the whole air, and covering the neighbouring country with a shower of dust, &c. to many miles distance. Great stones, also, of some tons weight, are often thrown to the distance of two or three miles, by such explosions. *Monf. Bouguer* tells us, that “he met with stones in *South-America*, of eight or nine feet diameter, that had been thrown from the volcano *Catopaxi*, by one of these blasts, to the distance of more than three leagues.” In *Ulloa’s* account, the whole plain, near *Latacunga*, is said to be full of pieces of rocks, some of which were thrown, from the same volcano, to the distance of five leagues.† If subterraneous vapours, when they have had nothing to confine them, have acted with such force, we may easily conceive that they must heave up, and cause a progressive swell in the surface of the earth, when their force was confined, and their motion directed by a particular passage.

The *eruptions* and *effusions* that have attended our earthquakes, have also borne strong marks of subterraneous vapour. That a vapour of sufficient force to shake and move the surface of a whole

† *Phil. Trans.* for 1760, p. 592.

whole country, should break out in many places, where it came near to the surface of the earth, is agreeable to the presumption of theory. Thus it has been with several of our earthquakes. In that of 1727, there was an eruption at *Newbury*, attended with an effusion of sand, containing small mixtures of sulphur, and a very noxious, ill-scented vapour. Strong sulphureous smells were observed in other places; and, as some supposed, there were also appearances of flame. In the earthquake of 1755, there were eruptions at *Scituate*, *Pembroke*, *Lancaster*, &c. with large effusions of sand, probably of a sulphureous nature. Whether this was the case with any of the other earthquakes, the accounts are not particular enough to determine. But in these, both the matter and smell attending the eruptions, afforded strong marks and evidence of subterraneous vapours.

The earthquakes of *New-England* have also made such alterations in the bowels, and upon the surface of the earth, as a strong subterraneous vapour would produce. Very considerable alterations might be expected in the bowels, and upon the surface of the earth, and in the system of springs, fountains, currents and streams of water, from a vapour of such force as to break thro' the surface of the earth, and of such extent as to reach from one country to another. Such effects have always followed the larger shocks. In that of 1663, incredible alterations are said to have been made in the surface of the earth at *Canada*, for many leagues through the country. Rocks and mountains were, in some places, thrown down, and considerably removed; and the channel in some parts of the river *St. Lawrence*, was very much changed and altered. In those of 1727 and 1755, the surface of the earth, in some parts of *New-England*, was considerably

considerably broken and changed ; and the whole system of fountains and springs, was greatly affected. Great alterations were made in wells, ponds, fountains and currents of water ; some were dried up, others opened ; new ones produced, and, in many, the kind, quality and quantity of the water was greatly changed.—Alterations in all respects similar to what might be expected from subterraneous vapours, fiercely driving along under the surface of the earth, with a force sufficient to move and shake so large a part of its surface.

This opinion agrees also *with the effects which the earthquakes have had on the water*. The earthquakes of *New-England* have been felt not only upon the land, but also upon the sea. Several vessels, which have been upon the coasts at the times of the larger shocks, have been very sensibly affected. To the people on board, the shocks seemed as if the vessel had struck upon a rock ; or rather, as if something had thumped against their bottoms. This, it is probable, was the very case ; and is agreeable to what might be expected from the operation of subterraneous vapours.

The earthquakes moved with a velocity sufficient to communicate the same kind of motion to the water that they did to the earth ; and thus caused a very deep, large and extensive swell or wave. This wave, arising from the bottom, rolled along with much the same velocity as the earthquake moved : the effect of which, when it came to a vessel floating upon the water, would be a very considerable stroke or thump against the bottom,—more or less violent, according to the violence of the shock, and the depth of the water.—And in this manner have vessels, upon the coast, been affected ;—some scarce perceiving it ; others not at all ; while to others it was pretty violent.

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There have been other effects upon the water, such as a surprising flux and reflux of the sea,—extraordinary agitations and commotions of the waters,—an uncommon destruction of fish, &c. These effects have not been common, and never but at a considerable distance from the coast of *New-England*. And they seem to be plain and evident marks and effects, of the discharge of the subterraneous vapours, at the bottom of the sea. Such a discharge, when small, would be sufficient to occasion the destruction of such fish as were near it : and when large, would put an end to the earthquake, and produce the most extraordinary agitations and commotions of the sea, by a furious eruption of vapours at its bottom ; which would immediately force their way through, or carry up before them, the whole body of water that lay over them.

And thus as to the *conclusion* :—It might be naturally expected, that as the vapours, by which the earthquakes were caused, were some time in growing ripe, fermenting, or in a state of previous preparation, they would not be wholly spent or discharged at once, but leave small remainders at particular places. Thus it has proved in all the great earthquakes we have had. The vapours, by which they have been produced, have not been wholly spent at the first shock : but what has remained, and what has gathered after a great explosion, has produced various small shocks in several places, for some time after the great ones :—thus wasting and evaporating by little and little, as they were collected and prepared at first ; till, by degrees, all has become quiet again.

Such have been the phenomena that have attended the earthquakes of *New-England*.—And to me, they appear to be such, as (viewed either together or apart) make it highly probable, that

that what moved under, and hove up the surface of the earth, was a *strong elastic vapour*.*

The *origin* or *production* of such a vapour, may be accounted for from the CONTENTS of the earth. Much the largest part of the contents of the earth, will always remain hidden from our view, and beyond the reach of our knowledge. We have, however, penetrated far enough below its surface to find, that many of the bodies it contains, are of such a texture, or contain particles of such a nature, as to generate, or be easily turned into vapour. This is the case with coals, salts, sulphur, nitre, air, water, most kind of minerals, and all substances which contain oily particles. Such bodies, at least some of the particles they contain, are easily and often turned into a very strong, subtle, elastic vapour. With some, nothing more is necessary to generate a very powerful vapour, than a bare *mixture* of different bodies. Thus equal quantities of powdered sulphur and iron filings, being mixed with water, soon become too hot to be touched; and in a little time emit flame and vapour. And if iron, oil of vitriol, and water, become mixed together, there will instantly arise a violent ebullition, with fumes copiously exhaling; and which are so very inflammable, that if set on fire, they go off at once with a loud explosion. The same is also effected by *fermentation*. Instances of very strong elastic vapours, produced this way, are so common and obvious, that particular cases need not be mentioned. All separable, mixt and compound bodies, may be the subject of this operation: and the easier they are separable, whether by means of

* From the phenomena which have been mentioned, it seems probable, that this elastic vapour was a fluid, of the same nature as that which is now called *inflammable air*.

of water, air, or heat, the more readily they ferment.—And when they do ferment, they will produce a vapour more or less strong, according to the quantities of the fermenting matter, and the degree of the fermentation. But in no method is a more powerful vapour produced, than by *fire*. What an amazing effect will a small spark of this have on nitre and sulphur, when made up into such a composition as that of gun-powder! How small a quantity of this powder, when on fire, will generate a vapour of sufficient force to burst the firmest rocks! Air, by the application of fire, becomes so elastic, as to break through all opposition.—And there are many effects produced by the vapour of water, when intensely heated, which make it probable, that the force of gun-powder is not near equal to it. And, in general, all combustible bodies are capable of being turned into vapour, by the action of fire.—And fire seems to be a fluid, which is spread through almost all bodies whatsoever. It certainly exists, in very large quantities, in the bowels of the earth.—Some parts, as the volcanoes are actually burning, and have been throwing out fire, flame, smoke, cinder, rocks and lava, for many ages.—And where there are no such appearances of it, it exists, and is diffused in great quantities. That this is the case is evident from hot springs,—the warmth that is always found in deep mines and pits,—and those burning mountains that have been thrown up from the bottom of the sea.—And when collected into large quantities, its effects on water, air, the fumes of fermenting minerals, and all kinds of combustible bodies, would be to generate a vapour more or less strong, according to the quantities of the minerals of which it was composed.

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Thus

Thus, in the *contents* of the earth, we find sufficient materials for the production of the most strong, active and powerful vapour ;—and such materials as do, in fact, produce most terrible volcanoes,—vapours that have hove up, and broke thro' the surface of the earth,—and earthquakes that have shaken the whole country, for twenty miles around *Vesuvius* and *Ætna*.—And such explosions and concussions are what all those countries are subject to, which abound with sulphur, nitre, and such combustibile materials.

As the *contents* of the earth will account for the *origin*, the *structure* of it will account for the *motion* and *direction* of a subterraneous vapour. Were the globe a perfect solid, there could be no motion of a subterraneous vapour under its surface. But this is not the case.—Instead of being a perfect solid, the earth is of a *cavernous structure* ; containing various pits, holes and caverns. Some of these are dry ; others are the fountains, or contain currents of water ; and others abound with the fumes of fermenting minerals, and with various kinds of vapour and effluvia. That the earth is thus of a cavernous structure, is evident from the mines, springs, and currents of water, that are found below its surface, in every country, and in almost every place. And it is probable, that many of these subterraneous caverns may be of a great extent ;—some running in a direct, and others in long, crooked, unequal passages.—And by thus winding, meeting, crossing and mixing with each other, they may form communications between very distant parts of the earth. The *manner* in which the solid and fluid parts of the earth are *disposed*, is also worthy of remark.—In some places, they are found promiscuously mingled and blended together, in a manner which has no apparent order

order or regularity. In other places, the various kinds of *solids* appear to be disposed with the utmost apparent regularity, in the form of different and distinct *strata* of clay, coals, salts, sulphur, minerals, &c. It is thus also with the *fluids*;—in many places, they are regularly collected into quantities, or fountains, within the bowels of the earth; in others, they are constantly and regularly moving in perpetual streams and currents: some of which are charged with sulphureous particles; others with those of iron; and others, with various other tinctures and mixtures.

And from this *Structure* of the earth, *the motion* of a subterraneous vapour would receive *its direction*. For vapours, generated and increasing in the bowels of the earth, if they found no vent upwards, must naturally take their course and rush fiercely along under the surface of the earth, according as they found subterraneous *passages* or *strata*, of proper materials to conduct them.—And it seems as if something of this nature must be the case in this part of *America*. That there should be a particular part of the country, as to width, to which the earthquakes of *New-England* have repeatedly reached; that they should all be of the same kind,—come from the same point,—and proceed in the same path;—these phenomena cannot be supposed to be the effect of what is called chance or accident. It is evident there must have been something which served as *conductors*. If *subterraneous passages*, of such extent as these earthquakes, should be admitted, it would be difficult to account for the width of the earthquakes, on that hypothesis. The more probable supposition seems to be, that there are some particular *strata*, which have served as fuel or conductors to the vapour. And that this was the case, seems further probable from the

fulphureous mixtures that have been thrown out at the different eruptions. Instances of these eruptions are mentioned in the accounts of the earthquakes of 1727 and 1755.—And they are such as make it probable, that there is some particular *stratum* under the surface of the country, which has served and will serve to direct the motion of the subterraneous vapour, from the places of its origin, to that of its grand final eruption.*

On this account of the Causes of the Earthquakes of *New-England*, it may not be amiss to remark, that part of it seems to be matter of *fact*, and part matter of *conjecture*. As the causes lie out of sight, and beyond the reach of observation, we have no way to come to the knowledge of them, but by general reasonings from the phenomena that fall under our observation. These phenomena, I may venture to say, have been fairly related :—but whether the inferences that have been drawn from them, are just,—the conjectures, such as are probable,—the conclusions, well supported,—and the evidence, such as might

* Such *strata* are not at all uncommon. Many countries are known to abound with, and to be distinguished by them. “We have an instance of it in the chalky and flinty countries of *England* and *France*, which (excepting the interruption of the channel, and the clays, sands, &c. of a few counties) compose a tract of about three hundred miles each way.” *Phil. Trans.* for 1760, p. 587. The volcanoes in the *Andes*, are in all probability derived from the same *stratum* of combustible minerals ; the extent of which cannot be less than five thousand miles,—for so far do the mountains and volcanoes extend.—And thus in *North-America*, if we may give credit to *L. Evans*, in descending from the mountains which adjoin to the western lakes, the same sets of *strata*, and in the same order, are generally kept up.

In some countries, earthquakes have ceased upon the breaking out of volcanoes. If there were volcanoes in this part of *America*, which might serve to interrupt the *stratum*, and as a vent for the subterraneous vapours to discharge themselves, it is probable the earthquakes of *New-England* would not run in such a regular manner, through such an extent of the country.

might have been expected,—these are submitted to the judgment of others. Hypotheses may be of use to put us upon further enquiry, and a more critical examination ; but are never to be received, any further than they are supported by proper evidence.

GENERAL REFLECTIONS on EARTHQUAKES.

THE preceding ACCOUNTS, OBSERVATIONS and CONJECTURES, have been confined to the earthquakes of *New-England*.—But they will naturally lead us to some GENERAL REFLECTIONS on the nature, use and effects of these formidable phenomena. Thus,

If we are right in our conjectures on the causes of earthquakes, we may conclude, that the globe always has been, and will be subject to such concussions. From the earliest ages, of which we have any accounts, this has been the case. Many parts of the earth bear the marks of great and furious eruptions ; not a few of which, were prior to all historical monuments and records. The eruptions of the noted *Ætna*, may be traced back an hundred years before the siege of *Troy*.* *Vesuvius* was a volcano before the foundations of *Herculaneum* and *Pompeii* were first laid. These cities were covered by an eruption of *Vesuvius*, A. D. 79. Their foundations and pavements are all of that melted and vitrified substance called *lava*, which *Vesuvius* had thrown out ;—which is a proof of great eruptions, prior to the foundations of these cities.† How long these volcanoes, or those in *Iceland*, the *East-Indian* islands, and

* According to M. D'Orville.

† Phil. Trans, for 1771. Art. 1.

and *South-America*, have been burning, we have no history or tradition ancient enough to inform us. Many of their effects bear the marks of more furious eruptions than any there have been in modern times. The soil for more than twenty miles, round *Naples*, by its cinder, stones, burnt matter and lava, appears to have been the production of very ancient subterraneous fires, earthquakes and eruptions.* The *Appenines*, a chain of mountains which divide the continent of *Italy* from north to south, and extend even to *Sicily*, discover many tokens of an internal fire; and were judged, by that celebrated philosopher, M. de la *Condemine*, to be a chain of ancient volcanoes. This is also the case with that long chain of mountains in *South-America*, known by the name of the *Andes*. These mountains run from 45° south latitude, to several degrees north of the line, and also throughout all *Mexico*; being, according to Monf. *Bouguer's* account, five thousand miles in extent. The series of volcanoes, formed by these mountains, is interrupted: many are totally extinguished; and there are many which are still burning; and many of the ancient ones frequently burst out again.† Several of the *West-Indian* islands, the *Azores*, *Teneriffe*, and most high mountains, either contain volcanoes, or, by the vestiges of calcination and vitrification, show the former effects of them.—And as several islands and mountains have been sunk, so we have authentic accounts of several that have been thrown up from the bottom of the sea, by subterraneous fires. Such effects with the relations of history, afford plentiful evidence, that the globe has always been subject to and greatly affected by subterraneous fires, earthquakes and volcanoes. The

* *Phil. Transf.* for 1771. Art. 1.

† *Condamine's Travels into Italy.*

The same causes which have produced such effects on the surface, are undoubtedly still existent in the bowels of the earth. Proper periods of time may be requisite for them to grow ripe, or gather strength sufficient to cause an explosion or earthquake. But as the materials from which subterraneous vapours are formed, constantly exist in the bowels of the earth, they will be as constantly fermenting; and thus increasing the quantity and force of the vapours, till they shall become sufficient to break through all opposition, and force for themselves a passage thro' the earth. And although they may in such ways be discharged from time to time; yet, so long as the same powers shall subsist in matter, new vapours will be produced; and, of consequence, the same effects, after proper intervals of time, will again take place. Nor are they to be viewed as marks of any disorder or irregularity in the works of nature. For,

Notwithstanding all their terrible effects, earthquakes seem to be a necessary consequence of such laws of nature, and powers in matter, as are, upon the whole, greatly beneficial to the globe. There is no phenomena in the whole course of nature, so formidable as that of an earthquake.—Nor is there any that has spread more universal horror, calamity and desolation. History, ancient and modern, abounds with accounts of large countries that have been shaken,—whole cities that have been sunk and covered,—and immense numbers of mankind that have been destroyed, by these dreadful convulsions of nature. In the earthquake which shook *Sicily*, in the year 1693, fifty-four cities and towns, with an incredible number of villages, were either destroyed or greatly damaged, and about sixty thousand persons perished. In that at *Jamaica*, in 1692, almost the whole of *Port-Royal* was swallowed up, and large numbers of
its

its inhabitants buried in its ruins.—And in the earthquake at *Lima* in *Peru*, in 1746, all the buildings in that city, and in the port of *Callao*, except about thirty, were sunk, or laid in ruins, and great numbers of people destroyed :—four hundred and fifty-one shocks, many of which were equal to the first, succeeding in the space of four months. The destruction of *Lisbon*, by the earthquakes in 1755, was also attended with the most tragical scenes of desolation, death and misery. And yet, notwithstanding all these dire effects of earthquakes, it is very possible, that the laws and causes from whence they arise, may be a necessary provision, and a real advantage to the globe. The power of gravity, the wind and water, rain, heat and cold, have occasioned the destruction of vast numbers of mankind : and yet they are a general advantage to the earth, and to its inhabitants ;—and such an advantage, that no creature could live on this globe without them. And since they produce an *overbalance* of good, they are to be esteemed advantageous and beneficial upon the whole ; although in some particular cases, they may be attended with very dangerous and fatal effects. This, it is probable, is the case with all the laws, powers and operations of nature ; and to all those agitations and concussions to which the earth is subject.

To enumerate all the ends to which these formidable phenomena may serve in the natural world, would require higher degrees of knowledge than it is probable we shall ever have of this subject. And yet, perhaps, we may see enough to convince us of the wisdom and benevolence of the Creator, in making the globe subject to such concussions. These extensive and powerful agitations tend to weaken the attraction, loosen the parts, and open the pores of the earth ; and thus to fit and
prepare

prepare it for the purposes of vegetation, and for the various kinds of produce that are necessary for the support of animal life. Were an insuperable bond of attraction to take place on the surface, or in the bowels of the earth, without something to oppose its power,—fluidity, motion, vegetation, and all nature would be at a stand. The power of gravity tends to this : And hence we find it necessary, by the operations of agriculture, to break the surface of the earth, to loosen its parts, and open its pores, and thus weaken its attraction, that it may be fit for the production of such fruit and grain as we want in the course of the year. An earthquake performs that in the bowels of the earth, which the various methods of agriculture perform on its surface.—And it is probable, that the former is equally necessary to the purposes of vegetation, as the latter.—And what seems to confirm these conjectures, it is observable, that those places which are most subject to earthquakes, are the most noted, *cæteris paribus*, for the fruitfulness of its soil, and the plenty of its produce. Thus *Italy*, *Peru*, *Manilla*, and especially *Ætna* and *Vesuvius*, places greatly subject to earthquakes, are celebrated for an uncommon fertility. There are other important ends which may be answered by earthquakes. Those subterraneous vapours, by which they are caused, seem necessary to prevent the inward parts of the earth from becoming too dense, compact and hard, in consequence of their attraction.—And when these vapours are collected in large quantities, it may be necessary to have them discharged into the atmosphere, to prevent a dissolution of the globe through the force of their elasticity or repulsion. It may also be necessary to have new subterraneous passages opened,—old ones diverted from their former courses,—and new communications establish-

ed between different countries,—that all parts of the earth may be supplied with such kinds and quantities of water and air, as the growth of bodies, in the bowels and upon the surface of the earth, may require ; and that the solid and fluid parts of the earth may be kept in their due place, connection and order.—And, in general, we may presume, from the analogy of nature, that there may be, and no doubt are, many ends and uses to which subterraneous fires and earthquakes may serve, of which we have as yet no ideas or conjectures. But however these things may be,

It is probable, that our knowledge of this subject will increase, as all other branches of natural knowledge have done, and by the same means, observation and reasoning. In the contents and structure of the globe, the Creator of it seems to have made provision for the production of subterraneous vapours and explosions. Earthquakes may of consequence be expected, at proper intervals of time, in every country and climate, so long as the earth shall continue to exist in its present form. As these events happen, posterity will have opportunity to examine their phenomena, to note their effects and operations, and to mark all their differences and agreements : and, of consequence, they will be obtaining more and more insight into their nature, causes and effects. The methods of reasoning which are now happily introduced into philosophical subjects, though their effects may be slow, are yet certain and progressive. Every age will be doing something for the next.—And the several philosophical societies already established, by collecting and recording observations, are, and will be, providing materials for the ages that are to come.—And when a sufficient number of observations shall be thus collected

ed, inferences may be drawn, and conclusions may be formed from them, of which, as yet, we have not the least thought or suspicion. It has been thus in all other branches of philosophy : and the same accuracy of observation and reasoning, when applied to the philosophy of earthquakes, will probably bring to light things, of which we have now no knowledge or conception.

From any knowledge we yet have of the nature and causes of earthquakes, nothing would appear more romantic, than to attempt to predict when such formidable concussions will happen. We know so little of their causes, much less when these causes will have collected sufficient force to burst forth and shake the adjacent country, that we have no way to form any rational conclusions as to the time when an earthquake will happen, from any inferences founded on the knowledge of the nature and operations of their causes. Nor can we receive much, if any, help from any *preceding signs* :—I do not mean those which fear and superstition have formed ; but from any regularity of their periods,—state of the atmosphere,—uncommon motion of wells, springs, and the like.—For if there is any connection between things of such a nature, and the happening of an earthquake, it is what we do not understand.

But our ignorance of these things ought not to be made an argument, that there is not in reality any regularity or order in these events ; or that it will always be impossible to discover so much of the nature and operations of natural causes, as to discern the same simplicity, order and harmony, in the several phenomena of earthquakes, as are apparent in many other works and operations of nature. In all those works of nature, of which we have any tolerable conceptions, stated laws, and a

steady regard to them, have been observed.—And this has been manifest and apparent in the same degree as our knowledge of any subject has been advanced. There was a time when universal confusion and disorder were supposed to prevail in the courses, motions and appearances of the heavenly bodies. But as the knowledge of the true astronomy increased, the most perfect order, harmony and proportion has been discovered in the motion and appearance of every star, planet and comet.—And it is now well known, that all the supposed irregularity in any of these bodies, was nothing more than want of knowledge, and confusion of ideas in the observer. If we may reason from analogy, the conclusion will be, that it is the same in all other cases. It can hardly be doubted, therefore, but that there is the same harmony, rule and order,—the same general and stated laws, in the causes and operations of earthquakes, as there are in all other events of nature. No reason can be assigned why these alone, of all the works of God, should be made up of irregularity and confusion. It must, therefore, be supposed, that earthquakes (like all other events that depend on natural causes) are subject to certain and determinate laws and rules, which are in themselves constant, regular and harmonious,—whether these laws, or this regularity, is known to us or not.

The ancient *Egyptians* and *Chaldeans*, by a long course of observations, are said to have been able to foretell the appearance of comets, and the approach of earthquakes.* The greatest philosophers have supposed their predictions of this kind were founded not on any knowledge they had of the laws and powers of nature, but on the vain arts of judicial astrology. This might be the case.—It is, however, to be wished, that we could

* *Diod. Siculus.*

could be a little more certain what knowledge the *Egyptians* pretended to in this matter. It is well known, that the sciences were much cultivated among that discreet people. Geometry and astronomy, if they were not begun, received very great improvements from them. The *Greeks* had all their astronomical learning from *Egypt*. *Pythagoras* got the knowledge of the true system of the universe from the *Egyptian* priests.—And their advances in several parts of the mathematics, were great and uncommon. How far they were acquainted with the astronomy of comets, I am not able to say. Some of the *Chaldeans*, and *Pythagorean philosophers*, taught many things as to the nature, orbits and revolutions of comets; which, though long disregarded, modern astronomy has adapted, and abundantly confirmed.* And that there was nothing impossible,—nothing romantic, in attempting to predict their appearance, the great *Halley* has fully demonstrated. And whether they might not have some knowledge as to the philosophy of earthquakes, which, thro' the ignorance and barbarousness of after ages, might be lost to the world, seems worthy of enquiry.

But however this may have been, it is at least possible, that regularity, order and laws may be discovered in these, as well as in other works of nature. It is, indeed, but very little that is yet known of the nature, causes and operations of these events. It will, probably, require the observations of many ages to digest and form them into a proper system.—And a long course of observations may open new scenes to posterity, and enable them to form conclusions,—I had almost said *predictions*,—which to us would appear wild, absurd and ridiculous. To me there appears as much ground for such a conjecture, as *Se-*

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* Gregory's Astronomy. Book v. sect. 1.

neca had seventeen hundred years ago for his, relative to comets; but which has literally been fulfilled.* But leaving these things to the ages that are to come,—

From contemplating these mighty works of nature, a philosophic mind will naturally rise in admiration and reverence, to the FIRST GREAT CAUSE OF ALL! In all the works of nature, we find plain marks of that wisdom, power and goodness, with which the whole plan, frame and constitution of it, was first formed and adjusted. As all natural effects take place in consequence of causes and laws derived at first from God, true philosophy agrees with the holy scriptures, in ascribing all such events to his agency. It was no doubt with a view *ultimately* to *moral* purposes, that the laws of nature were first established: and nothing can be better adapted than many of their operations, to awaken and direct the attention of mankind to the supreme Governor of the world. By the operation of natural causes, the Deity often ‘ariseeth to shake terribly the earth.’ ‘He looketh on the earth, and it trembleth: he toucheth the hills, and they smoke.’ ‘He removeth the mountains, and overturneth them in his anger.’ ‘The pillars of heaven tremble, and are astonished at his reproof.’

Amidst such convulsions of nature, strong impressions of the power and majesty of God, will naturally take possession of the human mind. Mankind will see and feel their dependence upon their Creator,—with the wisdom, benefit and advantage of

* ‘A time,’ said this excellent philosopher, ‘will come, when those things which now lie hid, will at last be brought to light, by length of time and the diligence of posterity: for it is not one age that is sufficient to make such great discoveries.’ *Seneca, Nat. Quest. lib. vii. chap. 25.* May we not venture to say the same of earthquakes?

of such a steady course of virtue, as leads to an habitual trust in his providence and protection. Such unusual and great events will powerfully awaken their attention to *morals*, and thus promote the advantage, although it may occasion loss and terror to mankind.

To pretend to be above fear, or to attempt to be unmoved with such concussions of nature, would argue, on the one hand, a folly or a pride unworthy a philosophic mind : and on the other, to give way at every such event, to such confusion of thoughts and passions, as leaves no command over the mind, is a weakness as much as possible to be avoided. Of this we may at all times be certain,—the present frame of nature will subsist so long as Infinite Wisdom and Goodness see it to be fit.—And no event will ever take place in the natural world, which was not foreseen by him who is the AUTHOR OF NATURE, and designed to answer some wise and benevolent purpose. Of his favour mortals may be sure, so long as they maintain a steady regard to the rules of virtue. This will always be productive of safety and happiness ; though the immediate effect of the present convulsions of nature, will probably be as the poet says,

*Terra tremit : fugere ferae, et mortalia corda
Per gentes humilis stravit pavor.*



IX. *An Account of West-River Mountain, and the Appearance of there having been a Volcano in it. In a Letter from DANIEL JONES, Esq; of Hindsdale, to the Rev. JOSEPH WILLARD. President of the University at Cambridge, V. Prof. A. A.*

Hindsdale, November 2, 1783.

S I R,

I RECEIVED your's of the 18th of August last, and observed the contents : and as I am not only willing, but desirous of doing all in my power to aid the literati in their pursuit of knowledge, immediately upon the receipt of your letter, (altho' I have often been upon *West-River Mountain*) repaired there again, with the best guides, and thoroughly explored the same.

The Mountain is situate about twelve miles north of *Massachusetts* line, on the east side of, and adjoining *Connecticut-River*, in the county of *Cheshire*, and state of *New-Hampshire*, and opposite the mouth of *West-River*, from which its name arises.

The Mountain, in all its parts, contains about three thousand acres of land, and is very uneven. The south and west ascents, very steep : the north and east not so steep, but very ragged.

On the south side of the Mountain, about eighty rods from the summit, there has been an eruption,—perhaps not within the present, or last century. The peasants, in the neighbourhood of the Mountain, discovered this place, and became possessed with the idea of gold dust being in the Mountain, and that it melted down into a solid body, by the extreme heat of
the

the Mountain, at the time the eruption happened : in consequence of which, they went to work in search of the supposed treasure ; and after fruitless searches, formed larger connections, entered into covenant with the proprietors of the land, and with one another, to make search for all kinds of mine and mineral. They have dug down about seventy or eighty feet ; and in some places, where the rocks permit, twenty feet wide ; but they are now impeded by the rocks, and the water that comes from the Mountain above the hole. The external parts of the hole is entirely rock, and in many places much burnt and softened. There are small holes in various places of the rock where they dig, like the arch of an oven, and the rock seems to be dissolved by heat ; the cinders and melted dross adhere to it, and hang down in drops like small icicles, something resembling in colour, the cinders of a furnace, or black glass, and it is so fastened to the rock, that it appears as if it was originally part of the same.

They dig out of the hole, near the surface, various strata of earth, or mineral ; and in digging a drain to let out the water, they find a great plenty of the same kind of earth ; and as it lies in the ground, the different complections are very curious to observe : there is a very fine soft yellow-oker, which, burnt, makes a good Spanish brown ; there is another strata, resembling levigated antimony, the particles very soft ; another of a faint yellow, fine, soft, and very greasy, which quality is not lost by lying on the surface of the earth, for a long time, exposed to the sun and air ; there is another that resembles a peach blossom in colour, but the texture more like the oker : and these various mineral, or earth, are not intermixed. At the mouth of the hole, there was blown out melted dross, which stuck to

the rocks ; and in the hole was found various pieces of stone, which appeared to be dissolved by fire, and the sides of the rock blackened by fire ; so that this hole must have been filled up since the eruption took place.

The miners inform me, that in the morning they frequently observe upon the earth that has been thrown out, something very white, and by touching it with their tongue suppose it to be salt-petre.

In my late search, I went to the top of the Mountain, directly above the place where the before-mentioned eruption happened, to see if there was a crater. The peak is small, and there are about twenty rods of ground on the summit, which is rather hollow, where water stands in a wet season (as is common in mountainous countries) but no regular crater. The hollow is oblong, and would have been, probably, had there been a great volcano (unless the heat had been so intense as to have dissolved a prodigious ridge of solid rock, about fifty feet to the west of this hole) so to the top of the Mountain, which forms one side of a large dingle, from the top to the bottom of the Mountain, four or five hundred feet perpendicular ; where immense quantities of rock have fallen down, occasioned, probably, by explosions in the Mountains, or earthquakes. That there have been various explosions in the Mountain, is beyond a doubt, and in various places, which have occasioned great quantities of stone and rock to fall from the Mountain ; but I am inclined to think these explosions are not frequent, as formerly, even fifty years ago ; for I am told by ancient people of veracity, who formerly dwelt at *Fort-Dummer* (opposite the Mountain) that there were frequently explosions, and fire and smoke were emitted.

The

The last explosion that I recollect, happened about five or six years ago, the noise resembling that of an earthquake, and the earth trembled considerably where I was, about four or five miles from the Mountain ; my herd of cattle were greatly terrified thereby, and run together through fear.

That there has been something more than a sudden explosion, every one that views it must be convinced : but that there has been any considerable volcano, so as to cause the earth above to fall in or settle, no one, I presume, will pretend.

I am, Sir, with great respect,
your very humble servant,

DANIEL JONES.

The Rev. JOSEPH WILLARD.



X. *An Account of Eruptions, and the present Appearances, in West-River Mountain. In a Letter from Mr. CALEB ALEXANDER, of Northfield, to Mr. CALEB GANNETT, Rec. Sec. A. A.*

Northfield, May 18, 1779.

S I R;

ACCORDING to your desire, I have visited the volcano upon the height of *West-River Mountain*, and shall do myself the pleasure to inform you concerning the various reports and particulars relating to this place.

How long since it was first discovered, I am not able to ascertain. An old gentleman informs me, that fifty years since, he heard noises on that Mountain, as loud as the explosion of a great gun. Some years after, similar noises were heard, at the distance of fourteen or fifteen miles. Several times very violent eruptions of fire have been seen, the flame ascending very high into the air. Once in the winter there was an eruption. The years when the preceding eruptions happened, I cannot inform: the last was twenty-seven years since; which was the most violent eruption ever known in that place: it was towards the close of a dark evening, when it was first perceived, being preceded by a louder noise than common; then directly was seen the fire, which was seen to burn for several hours.

What I have written is by information: yesterday I was at the place myself. It is nearly upon the top of a very steep craggy mountain: by observation, I apprehend there were two places where the fire issued out; one of which is between two solid rocks, nearly a foot in diameter, but almost filled with the calcined matter caused by the fire, part of which appears similar

lar to burnt sand, intermixed with cinders. The surface of the rocks, for a considerable distance, indicates that there have been very intense fires, and probably melted matter upon them, for they are turned into perfect cinders.

The other place where the eruption has been is so destroyed, that I can inform but little with regard to it : only upon one side the rock is greatly calcined.

A number of gentlemen, apprehensive that there is some valuable mine in this Mountain, have undertaken to penetrate the bowels thereof. Accordingly, they have dug nearly eighty feet, in a perpendicular direction, into the Mountain, following a vein of matter, appearing similar to oker, both yellow, red, and brown ; also, very often, they find pieces of cinders, like those which I have sent you. This vein, in some places, is sixteen feet in diameter, in other places not more than five.

In digging, they often find strata of this calcined matter, with a considerable mixture of other substance, appearing as if it had been intensely burned. I descended to the bottom of this (truly hideous) pit, and observed, that the rocks, in many places, were turned into cinders.

I am not able to determine, whether there be any thing of a sulphureous nature on this Mountain ; but this I dare affirm, that there have been several eruptions : but whether it may, with propriety, be called a volcano, I know not. This determination is submitted to the judgment of gentlemen more acquainted with the nature of volcanos, than I can pretend to be.

I send you, for observation, two pieces, that were taken one from the top and the other seventy feet under ground.

I am, &c.

CALEB ALEXANDER,



XI. *Observations made at Beverly, Lat. 42° 36' N. Long. 70° 45' W. to determine the Variation of the magnetical Needle. By the Rev. JOSEPH WILLARD, President of the University at Cambridge, V. Pres. A. A.*

AN attention to the variation of the magnetical needle, it is well known, is of great importance at sea, nor is it of small consequence upon the land; especially in *North-America*. From the first settlement of this country, the lines between towns, and between lots of land appropriated to individuals, have been determined by the magnetical needle. If the variation always continued the same, no difficulty would ensue, in again tracing the lines, upon the same magnetical course; but as it alters from time to time, the lines run in any succeeding years must deviate from the first, and from one another, unless proper allowances are made for the alteration.

From the want of a sufficient number of observations, and of attention to this subject, in those who have surveyed the lands in this country, difficulties have arisen at one time and another, between towns and individuals. To remedy this inconvenience for the future, this Academy, some time ago, recommended magnetical observations, to determine the variation, which it is to be hoped will be made in various parts of the country, and at proper intervals of time, and be uniformly attended to by our surveyors. Since this recommendation, I have endeavoured to determine the variation at *Beverly*, with as much exactness as I was able. With this view, I procured an azimuth compass, of Dr. *Gowin Knight's* invention. It appears to be good

good of its kind, and is furnished with a vernier, pointing out the azimuth to 5' ; but the eye may pretty easily determine by it to 2', and sometimes to 1'. To observe by this compass, I ascertained the going of my clock to great exactness, and on five different days, took several magnetical azimuths, both before and after the sun passed the meridian, and noted the moments, which I have put down in apparent time. For these times, I have calculated the true azimuths by spheric trigonometry, and have carried out the variation for each observation separately. On two days, I also determined the variation, by taking magnetic azimuths, at corresponding altitudes of the sun, making proper allowances for the change of declination, between the observations of the forenoon and afternoon. On each of the days, some of the observations differ several minutes from others ; but this I cannot attribute to want of attention, as I am conscious that I made them with all the care in my power. The differences, I suspect, principally arose from the difficulty of determining, with entire exactness, when the shadow from the hair was on the line beneath ; and when in two observations, the error should be on different sides, the sum might make a number of minutes. But I have the satisfaction of finding the mean results for the several days well agreeing with each other, which is a good evidence that the result of the whole must be, at least, very near the truth.

These observations and deductions are now humbly submitted to the Academy, with wishes that they may subserve the designed purpose.

JULY

320 *President WILLARD's magnetical Observations,*

JULY 27, 1781.

Ap. times of obf.	Sun's mag. az. per obf.	Sun's true az. per cal.	Varia. of the need.
11 ^h 34'	S 8° 2' E	S 15° 9' E	7° 7 W.
11 36	7 0	14 2	7 2
11 50	S 1 10 W	5 57	7 7
11 58	5 55	1 15	7 10
12 4	9 28	S 2 26 W	7 2
12 20	18 45	11 45	7 0
12 26	22 15	15 10	7 5
12 28	23 30	16 17	7 13

Variation of the needle by a mean of 8 observations, July 27,

7 5 $\frac{1}{2}$

JULY 28.

11 ^h 44	S 2° 25' E	S 9° 19' E	6° 54' W.
12 4	S 9 15 W	S 2 20 W	6 55
12 6	10 35	3 30	7 5
12 8	11 45	4 40	7 5
12 22	19 45	12 46	6 59
12 26	22 5	15 2	7 3
12 30	24 15	17 16	6 59

Variation by the mean of 7 observations, of July 28.

7 0

JULY 30.

11 52	S 2 30 W	S 4 37 E	7 7 W.
12 2	8 15	S 1 10 W	7 5
12 6	10 28	3 28	7 0
12 18	17 28	10 19	7 9
12 26	21 55	14 47	7 8

Variation by the mean of 5 observations, of July 30,

7 5 $\frac{1}{2}$

JULY 31.

11 29 32"	S 10 10 E	S 17 7 E	6 57 W.
11 39 32	4 35	11 37	7 2
11 43 32	2 20	9 23	7 3
11 51 32	S 2 5 W	4 51	6 56
11 55 32	4 32	2 34	7 6
11 59 32	6 40	0 16	6 56
12 1 32	7 50	0 53 W	6 57

Variation by the mean of 7 observations, of July 31,

6 59 $\frac{1}{2}$

AUGUST 1.

11 53 52	S 3 32 W	S 3 28 E	7 0 W.
11 59 52	7 2	0 4	7 6
12 1 52	8 0	1 4 W	6 56
12 3 52	9 10	2 12	6 58
12 15 52	15 58	8 59	6 59

Variation by the mean of 5 observations, of August 1,

6 59 $\frac{1}{2}$
Variation

Variations determined by magnetic azimuths, taken at equal altitudes of the sun, forenoon and afternoon.

AUGUST 6.

A. M.	P. M.	Difference.	$\frac{1}{2}$ Diff. = Variation.
68° 28'	82° 30'	14° 2'	7° 1' W.
65 30	79 20	13 50	6 55
63 50	77 35	13 45	6 52 $\frac{1}{2}$
63 30	77 15	13 45	6 52 $\frac{1}{2}$
63 0	77 0	14 0	7 0
62 30	76 32	14 2	7 1

Mean variation by the above six observations of August 6,
Equation for change of declination,

Variation,

6 57
+ 4
7 1

AUGUST 15.

67 30	81 30	14 0	7 0
67 10	81 5	13 55	6 57 $\frac{1}{2}$
66 42	80 40	13 58	6 59
66 15	80 18	14 3	7 1 $\frac{1}{2}$
66 2	79 55	13 53	6 56 $\frac{1}{2}$
64 45	78 40	13 55	6 57 $\frac{1}{2}$
64 12	78 8	13 56	6 58
63 58	77 48	13 50	6 55
63 37	77 35	13 58	6 59
63 0	77 6	14 6	7 3
61 46	75 45	13 59	6 59 $\frac{1}{2}$
61 20	75 26	14 6	7 3
60 58	74 50	13 52	6 56
58 50	72 45	13 55	6 57 $\frac{1}{2}$
58 30	72 25	13 55	6 57 $\frac{1}{2}$
58 15	72 10	13 55	6 57 $\frac{1}{2}$
57 40	71 30	13 50	6 55
57 10	70 58	13 48	6 54
56 43	70 42	13 59	6 59 $\frac{1}{2}$

Mean variation by the above nineteen observations,
Equation for change of declination,

6 58 $\frac{1}{4}$
+ 5

Variation by nineteen observations of August 15,

Ditto fix 6,
Ditto five 1,
Ditto seven July 31,
Ditto five 30,
Ditto seven 28,
Ditto eight 27,

7 3 $\frac{1}{4}$
7 1
6 59 $\frac{4}{5}$
6 59 $\frac{4}{5}$
7 5 $\frac{4}{5}$
7 0
7 5 $\frac{3}{4}$

Varian. by the mean of seven days, containing fifty-seven obs. 7 2

322 *Professor SEWALL's Magnetical Observations, made at Cambridge.*

XII. *Magnetical Observations, made at Cambridge. By STEPHEN SEWALL, F. A. A. Hancock
Professor of the Oriental Languages in the University.*

THESE observations were made at my house, with the accurate and elegant variation compass of Nairne's construction, belonging to the University, with which I was favoured by Professor Williams. The meridian-line, to which the instrument was applied, is presumed to be accurately true; no pains were spared to make it so.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
April 15	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
16	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
17	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
18	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
19	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
20	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
21	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
22	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
23	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
24	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
25	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
26	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
27	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
28	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
29	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
30	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Mean,	6	39	40	6	44	36	6	41	40	6	48	48	00	6	45	00	00

6° 49' 35" Mean of the observations.

* Needle vibrating.

† Needle vibrating to 43'. Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "	° / "
May 1	6 39	6 46	6 41	6 40	6 54	6 52	6 48	6 51	6 47	6 59	6 42						
2	6 35	6 41				6 43	6 51		6 54	6 49							
3	6 41					6 55	6 58	7 08	6 54	6 53	6 53	6 46					
4	6 37	6 50	6 39			6 55	6 55						6 37	6 48	6 58	6 34	
5	6 43	6 40	6 44			6 56	6 54	6 56	6 54				6 43	6 48			
6	6 32					6 54	6 50	6 53	6 55				6 40	6 45		6 38†	
7									6 57				6 45	6 45			
8									6 52				6 44	6 42	6 42		
9									6 54				6 46	6 44	6 56		
10									6 51				6 48	6 49	6 48		
11									6 44				6 46	6 48	6 44		
12									6 48				6 48	6 48	6 44		
13									6 42				6 48	6 48	6 44		
14									6 42				6 48	6 48	6 44		
15									6 42				6 48	6 48	6 44		
16									6 42				6 48	6 48	6 44		
17									6 42				6 48	6 48	6 44		
18									6 42				6 48	6 48	6 44		
19									6 42				6 48	6 48	6 44		
20									6 42				6 48	6 48	6 44		
21									6 42				6 48	6 48	6 44		
22									6 42				6 48	6 48	6 44		
23									6 42				6 48	6 48	6 44		
24									6 42				6 48	6 48	6 44		
25									6 42				6 48	6 48	6 44		
26									6 42				6 48	6 48	6 44		
27									6 42				6 48	6 48	6 44		
28									6 42				6 48	6 48	6 44		
29									6 42				6 48	6 48	6 44		
30									6 42				6 48	6 48	6 44		
31									6 42				6 48	6 48	6 44		
Mean,	6 38	6 40	6 46	6 42	6 48	6 50	6 52	6 53	6 52	6 52	6 50	6 46	6 43	6 46	6 45	6 44	6 47

6° 46' 30" Mean of the observations.

* Needle vibrating. † Needle vibrating. ‡ Needle vibrating 10'. Small Aurora Borealis.

|| Needle vibrating prevented an observation. § Small Aurora Borealis.

Time.

Professor SEWALL'S Magnetical Observations, made at Cambridge.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782. June 16 39	6 45	6 38	6 36	6 37	6 47	6 43	6 46	6 52	6 50	6 55	6 49	6 45	6 45		6 40		6 53
3				6 37	6 37	6 46	6 47	6 50	6 53	6 50	6 46	6 43	6 44	6 44			6 49
4				6 36	6 36	6 45	6 45	6 50	6 53	6 52	6 38	6 59	6 51	6 51			6 48
5						6 43		6 50	6 53	6 52			6 46	6 42	6 46	6 40	
6								6 50	6 53	6 52			6 56†	6 42	6 46	6 40	
7								6 50	6 53	6 52			6 44	6 38	6 48	6 51	
8								6 50	6 53	6 52			6 45	6 42	6 48	6 43	
9								6 50	6 53	6 52			6 45	6 47	6 47	6 47	
10								6 50	6 53	6 52			6 43†	6 52	6 44	6 44	
11 6 38								6 50	6 53	6 52			6 43	6 46			
12 6 38								6 50	6 53	6 52			6 43	6 46			
13 6 38								6 50	6 53	6 52			6 43	6 46			
14								6 50	6 53	6 52			6 43	6 46			
15								6 50	6 53	6 52			6 43	6 46			
17								6 50	6 53	6 52			6 43	6 46			
18 6 37								6 50	6 53	6 52			6 43	6 46			
19 6 37								6 50	6 53	6 52			6 43	6 46			
28								6 50	6 53	6 52			6 43	6 46			
29								6 50	6 53	6 52			6 43	6 46			
Mean.	6 37	50 6 39	30 6 38	30 6 38	39 27 6 39	44 36 6 44	47 22 6 47	52 38 6 52	51 55 6 51	52 55 6 52	47 22 6 47	46 00 6 46	46 20 6 46	45 20 6 45	44 40 6 44	45 45 6 45	48 00 6 48

6° 45' 41" Mean of all the observations.

* Thunder-storm. + Thunder in the west. † Needle vibrating. § Small Aurora Borealis.

Time.

Professor SEWALL'S, Magnetical Observations, made at Cambridge.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
July 1	6 10	6 00	6 28	6 35	6 41	6 40	6 49	6 51	6 51	6 51	6 51	6 51	6 51	6 44	6 44	6 44	6 44
2			6 35	6 21	6 58	6 40	6 49	6 54	6 51	6 51	6 46	6 50					
3	6 39	6 39	6 39	6 39	6 39	6 44	6 51	6 51	6 51	6 51	6 51	6 40					
4			6 32	6 48	6 41	6 47	6 48	6 48									
5			6 31			6 56	6 54	6 47	6 56	6 52	6 41	6 41	6 41	6 47			
6			6 36	6 36		6 55	6 47	6 47									
8			6 47	6 35													
10		6 28	6 37	6 42		6 48	6 55	6 57	6 44							6 34	6 32
11	6 41	6 41	6 42	6 44		6 49	6 50	6 47	6 54							6 52	6 52
12			6 44	6 37		6 48	6 55	6 58	6 54	6 51				6 41			
13			6 35	6 43		6 51	6 54	6 53	6 53	6 49	6 43	6 41					
15			6 34	6 47		6 47	6 50	6 54	6 48	6 49	6 46	6 48	6 51	6 49			
16		6 37	6 45	6 41		6 52	6 51	7 00	6 52	6 51	6 46	6 48	6 51	6 49			
17			6 38	6 44												6 49	6 47
18			6 38	6 41		6 54	6 57	6 53	6 56				6 52	6 50		6 50	6 47
19					6 43	6 46	6 58	7 00					6 53	6 56			
20			6 39	6 42		6 50	6 50	6 56	6 53	6 51		6 48	6 56	6 56		6 47	
22			6 41	6 44		6 48	6 50	6 49	6 49	6 47		6 40	6 45	6 45		6 45	
23			6 29			6 52	6 47	6 58	6 52	6 47	6 47	6 44	6 45	6 38	6 51	6 32	7 03
24			6 43			6 47	6 51	6 53	6 51		6 49	6 41	6 41	6 41	6 41	6 41	6 41
25				6 31		6 43	6 48	6 53	6 53	6 53	6 46	6 40	6 38	6 38	6 44	6 49	
26			6 34	6 35		6 49	6 54	6 53	6 53	6 53	6 42	6 44	6 44	6 44	6 44	6 44	
27			6 32	6 37		6 54	6 50	6 54	6 50	6 50	6 45	6 45	6 45	6 47			
29			6 38	6 42		6 45	6 48	6 48	6 48	6 51	6 45	6 45	6 45	6 45			
30			6 33	6 38		6 58	6 50	6 50	6 50	6 49	6 45	6 45	6 39	6 39			
31			6 33	6 38		6 57	6 50	6 55	6 48	6 49	6 45	6 45	6 39	6 39			
Mean.	6 40	6 35	6 36	6 39	6 41	6 43	6 49	6 53	6 51	6 50	6 46	6 44	6 45	6 43	6 45	6 44	6 47

6° 45' 15" Mean of all the observations.

* Thunder-storm.

† Needle vibrating.

‡ Vibrating to 7° 03'. Aurora Borealis.

‡ 10^h. 6° 34'.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.																	
Aug. 1	6 39	6 39	6 39	6 39	6 39	6 41	6 44	6 48	6 46	6 48	6 42	6 41			6 48	6 40	
2	6 34	6 42	6 41	6 47	6 42	6 49	6 47	6 51	6 51	6 50	6 45	6 47	6 44		6 48		
3	6 41	6 41	6 41	6 47	6 47	6 47	6 49	6 49	6 51	6 51	6 47	6 47	6 44		6 40		
5	6 31	6 39	6 39	6 39	6 39	6 43	6 50	6 52	6 48	6 52	6 47						
6	6 37	6 37	6 37	6 45	6 45	6 51	6 53	7 01	6 49	6 47	6 46	6 46		6 46			
7	6 38	6 37	6 37	6 45	6 45	6 51	6 58	6 55	6 41	6 47	6 49	6 46		6 41			
8	6 36	6 42	6 42	6 42	6 42	6 46	6 55	6 54	6 54	6 48	6 52	6 47		6 45			
9	6 28*	6 47*	6 47*	6 45*	6 45*	6 55	6 50	6 53	6 53	6 51	6 45	6 47	6 43	6 38			
10	6 32	6 36	6 36	6 42	6 42	6 45	6 47	6 52	6 53	6 48	6 46		6 49	6 49		6 40	
12	6 35	6 35	6 35	6 47	6 47	6 47	6 52	6 52	6 54	6 50	6 49			6 49		6 49	
13	6 35	6 41	6 41	6 41	6 41	6 47	6 45	6 52			6 49						
14	6 31	6 41	6 41	6 47	6 47	6 47	6 45	6 52			6 49						
15	6 34	6 47	6 47	6 47	6 47	6 47	6 45	6 52			6 49						
17	6 37	6 44	6 44	6 44	6 44	6 47	6 47	6 46			6 41	6 43	6 43				
19	6 31	6 40	6 40	6 36	6 36	6 47	6 51	6 55	6 51	6 47	6 41	6 43	6 43	6 43		6 35	
20	6 38	6 38	6 38	6 46	6 46	6 46	6 54	6 48	6 53	6 43	6 43	6 43	6 43	6 43			
Mean,	6 35 26	6 40 11	6 42 48	6 42 48	6 42 48	6 47 17	6 50 09	6 51 44	6 50 23	6 48 38	6 45 55	6 44 30	6 44 24	6 43 43	6 45 00	6 41 41	

6° 44' 48" Mean of all the observations.

The mean of all the observations, from May to August, makes the variation 6° 46' 22" W.

* Needle vibrating.

XIII. *An Historical Register of the Aurora Borealis, from August the 8th, 1781, to August 19, 1783. By CALEB GANNETT, A. M. Rec. Sec. A. A.*

Aug. 8, **A**N Aurora Borealis appeared in a common form, 1781. from eight o'clock till after ten. A luminous arc extended horizontally from north-west to north-east. The height of the arc, about 25° . A thick dusky vapour lay below. A few small strice ascended from the body of light. At $10^h 15'$, a column of light ascended from about north-north-west,—passed north of *Arcturus*, and crossing the meridian in the zenith, extended to the east, to about 30° of the horizon. Thus it remained for several minutes, and then moved slowly southward, till $10^h 45'$, when it vanished.

Meteors appeared in great numbers, shooting, in general, from north-west to south-east.

22. An Aurora Borealis,—of little extent, and faint.

23. ditto, ditto.

Sept. 18. ditto, ditto.

19. Appeared an auroral segment, extending from north-north-west, nearly east, supported by a dark vapour. A second luminous segment soon appeared above the first,—a thick dusky vapour intervening between the two. Some strice proceeded from the uppermost segment, which appeared to curve directly towards the zenith. About ten o'clock, a column of light shot up from the east, and crossing the meridian north of the zenith, passed some degrees west of the meridian. At eleven o'clock, appeared a number of coruscations; after which, the whole declined, till an entire disappearance.

Sept.

Sept. 25. At 7^h 30', an auroral arc appeared. Its meridional height about 53°. At 7^h 45', striæ proceeded from the arc towards the zenith—their colour, in general, white.—Those striæ, from being regular, soon appeared like broken sheets of light. At 8^h 10', the various interrupted striæ, rising from west-south-west to east-south-east, concentrated at about 10° south of the zenith. Glades, diverging from that point, extended to 15° in length, in every direction. After remaining in this state about seven minutes, the northward radii recoiled towards the centre. The whole phenomenon, from that time, decreased rapidly. At 8^h 20', nothing more than a common Aurora was visible. The striæ from west-north-west were very red, and attended with corruscations. At 8^h 26', the height of the luminous arc not more than 40°. Two or three small striæ; also, very thin white corruscations observable, whose horizontal extent was from west to north, and vertical to 10° south of the zenith. At 8^h 30', corruscations ceased, and the light in the north scarcely so much as to attract notice. At 8^h 37', the light increased.—Striæ began to ascend from the east, very red.—The general arc appeared to generate new arcs, which travelled southward, till the uttermost reached the zenith at 8^h 43'. Between the arcs, which were not quite regular, proper sky appeared,—in some parts, 5° in width, in others 3°. At 8^h 46', regular striæ ascended from north-west to east, to 5° south of the zenith, and terminated in a segment of a circle, whose diameter was about 9°. A quantity of the vapour, in appearance like a small, thin, white, irregular cloud, collected at about 6° south of the fore-mentioned segment. At 8^h 54', the striæ continued;—the segment, in which they terminate, enlarged.—From nine o'clock, a gradual decrease, till the whole disappeared. Oct.

Oct. 15. At 8^h. 16', a luminous arc commenced in a point within two or three degrees of the horizon, nearly east.—Thence diverging, it passed about 8° south of *Pleiades*, and proceeding between the stars in *Andromeda's Shoulder* and those in his left arm, crossed the meridian at about 13° south of the zenith, and extended to about 20° west of the meridian. At 5° altitude, the light was vivid and strong. From that height the light became more faint, till it became imperceptible at the afore-mentioned distance west of the meridian. The whole advanced south slowly, and disappeared at 8^h. 33', Auroral light was visible also from north-west to north.

19. A small Aurora.

Nov. 13. Ditto.

14. Ditto.

15. Ditto.

19. An Aurora extended from north-west to north-east.—White, except a red spot in the north-east :—and in the north-west, red and yellow. Striæ,—numerous, but not long.

March 9, 1782. A small Aurora.

April 2. Ditto.

4. Ditto.

14. Ditto.

May 9. Ditto.

22. From an extensive Auroral arc, striæ proceeded, till they almost reached the zenith. Their motion, at first, regular, afterwards, flashing and quivering.

July 9. A small Aurora.

10. Ditto.

Aug. 26. An Aurora. Striæ,—white but not long.

S 4

Sept.

Sept. 13. An Aurora continued through the night. Its horizontal extent, from west-south-west to north-east. Its complexion, white and vivid. Some striæ, though not numerous. In the west, the dusky vapour, near the horizon, appeared in two segments of a circle; one extending southward, the other northward.

14. An Aurora afforded a few striæ. One striæ, generated from the southern limit of the horizontal light, ascended almost to the zenith. It diverged very much in its ascent. After continuing at its greatest height for a minute or two, it subsided to about 50° altitude. At 10^h 30', the lower part, at about 15° altitude, became detached from the light below, and in the form of a narrow glade, remained suspended for several minutes, and then vanished.

22. At ten o'clock, a yellow stria of Auroral light appeared single in the west-south-west, without any dusky vapour beneath it; but rising from about 20° above the horizon, out of a smoky haze, and ascending to 55° altitude. It continued bright a few minutes, and then became faint. Three small striæ, at a small distance west of the former. After a continuance of about a quarter of an hour, the whole disappeared.

29. A small Aurora.

30. An Aurora—Inconsiderable through the evening. At twelve o'clock, striæ were numerous, frequent, and their motion brisk and undulatory.

Oct. 2. A small Aurora.

9. Ditto.

10. Ditto.

26. Ditto.

Jan. 26, 1783. Ditto.

Feb.

Feb. 2. A small Aurora.

21. Ditto.

27. Ditto. A few white striæ.

March 2. Ditto.

9. Ditto.

27. Ditto.

29. An Aurora was visible at the horizon, extending from north-west to nearly north-east. The whole arc, included within those limits to about 12° altitude, quite luminous. At $7^{\text{h}} 20'$, the usual dusky appearance commenced at the horizon, and increased till it became about 15° altitude. Light proceeded from the upper part, not as from the periphery of a regular arc, but from different heights. Striæ, frequent and disconnected, often appearing like rare white luminous clouds, varying their position and continually rising, till $7^{\text{h}} 50'$ they reached the zenith. Striæ more prevalent, passing the zenith. At 8^{h} , appeared a detached bright Auroral cloud in the south-east, within about 30° of the horizon.—Another long similar cloud in the south-west, passing swiftly downward to the same distance from the horizon;—thence, with a quick motion, westward;—then vibrated from east to west in an arc of several degrees. Each Auroral cloud frequently disappeared in an instant, then revived with equal, or superior, lustre.—Thus they continued a few minutes, and then entirely vanished. The striæ, which were hitherto frequent and brisk, tho' irregular, appeared to collect at about 5° south of the zenith, and there formed a large body of light.—Soon succeeded new shootings of striæ,—strong and regular; and below them, a frequent flashing of light. Between the striæ and luminous glades was the same dusky appearance, as in the cloud near the horizon. At $8^{\text{h}} 15'$, a corona formed at about 3°

south of the zenith, surrounding a small unilluminated circle. Dilated striæ proceeded from it in every direction. The corona soon changed its form, and became two segments of a circle, convex towards the centre of the corona. Radii proceeded nearly north and south, diverging. These presently ceased. At 8^h. 25', faint glades of light remained near the zenith, entirely detached from a large body of light extending from west-north-west to nearly east.—These in a tremulous motion, and frequently shooting very nimbly with increased lustre. At 8^h. 40', light shooting briskly from east-north-east in their glades, a little south of the zenith, to about 18° west. Several apparently compact spots of light near the zenith, below which, corruscations were very brisk. Calm till 8^h. 45'.—Wind then fresh from west. At 9^h. 30', the Aurora, for three quarters of an hour past, having been upon the decline, settling down into a general body of light of a dull appearance, without a very dusky cloud near the horizon,—now re-commenced in vivid striæ from the top of a black arc, about 25° altitude. At 9^h. 35', the striæ, from shooting very nimbly, became corruscations,—passed considerably south of the zenith, and continued several minutes in very quick vibrations. At 9^h. 50', no uniform dusky appearance near the horizon,—the light appearing in detached clouds from thence upwards, dancing and flashing to the zenith. At 10^h. 15', subsided into a general body of light.

March 30. A small Aurora.

April 3. Appeared a number of Auroral spots. After a short continuance, they vanished. No other Auroral light visible.

7. In the beginning of the evening, appeared a common white Aurora, forming an agreeable arc at about 20° altitude, extending

extending from north-west to north-east, supported by a thick dusky cloud, as usual ; through which several stars were plainly visible, especially one very near the horizon. At eight o'clock, striæ began to shoot. From 8^h. 15' to 8^h. 30', the light shot into different forms, detached in large spots or clouds. At 8^h. 30', a column of light arose from west-north-west ; and, passing about 15° north of *Procyon*, extended several degrees east of the meridian. At the same time, another column ascended from nearly east, at a considerable distance from the horizon,—passing a few degrees south of the other, and terminating a little west of the meridian. Those parts of the heavens included between the Auroral clouds, had a similar appearance with the dusky cloud, which usually appears beneath an Auroral arc. Stars were very visible in those included parts. The two columns from east and west, moved slowly south a few minutes, and then disappeared. Afterwards, the light decreased till nine o'clock, when it became an ordinary Aurora.

April 11. A small Aurora.

27. Ditto.

May 13. An Aurora commenced in the beginning of the evening ;—ascended in striæ ;—afterwards changed into whitish clouds, very thin, and in detachments passed the zenith,—travelled southward, and continued visible within 20° of the horizon. It soon declined, and in a little time was reduced to a common Aurora.

29. A small Aurora.

Aug. 1. Ditto.

16. Ditto.

19. Ditto.

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XIV. *A comparative View of Thermometrical and Barometrical Observations, at Cambridge.* By
the Rev. EDWARD WIGGLESWORTH, S. T. P. Hollis, F. A. A.

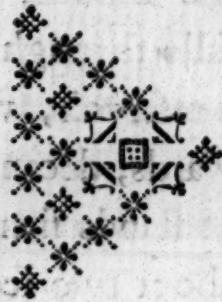
A comparative View of Thermometrical Observations.

	1780.			1781.			1782.			1783.		
	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.
January,				48½	13	35½	46	2	25	44	0	27
February,				45	9	36	41	1	27	55	0:1½	34
March,				50½	25	25½				59	13	36
April,				59	35	24				77	35	52
May,				77	41	36				77	46	59
June,				78	50	28				85	54	72
July,				86	65	21				91	62	72
August,				85½	63	22½	84	58½	72	88½	56½	70
September,				81	57	24	85½	49½	65	72	45	60
October,							66	39½	51	62	38	50
November,				54	21	33	52	20	38	53	19	36
December,				41	15	26	56	12	33	61	12	32

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A comparative View of Barometrical Observations.

	1780.			1781.			1782.			1783.						
	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.	Mean.
January,					30 30	28 83	1 47	29 66	30 57	29 40	1 17	30 05	30 33	29 04	1 29	29 64
Feb.					30 16	29 06	1 10	29 66	30 55	29 39	1 16	29 97	30 34	29 20	1 14	29 85
March,					30 26	29 16	1 10	29 76				30 12	28 91	1 21	29 71	
April,					30 18	28 96	1 22	29 64				30 30	29 40	0 90	29 86	
May,					30 05	29 41	0 64	29 75				30 32	29 42	0 90	29 86	
June,	30 09	29 19	0 90		30 03	29 32	0 71	29 76				30 27	29 52	0 75	29 86	
July,	30 20	29 50	0 70		30 19	29 71	0 48	29 98				30 18	29 47	0 71	29 87	
August,	30 13	29 61	0 52	29 90	30 27	29 66	0 61	30 00				30 20	29 49	0 71	29 87	
Sept.	30 15	29 38	0 77	29 82	30 40	29 67	0 73	30 02	30 24	29 69	0 55	29 97	30 23	29 42	0 81	29 82
October,	30 25	29 64	0 61	29 98					30 24	29 42	0 82	29 82	30 29	28 98	1 31	29 74
Nov.	30 41	28 90	1 51	29 73	30 50	29 15	1 35	29 76	30 50	29 20	1 30	29 80	30 39	28 72	1 67	29 70
Dec.	30 27	28 83	1 44	29 75	30 37	29 00	1 37	29 75	30 30	29 04	1 26	29 76	30 25	28 68	1 57	29 68



XV. *Meteorological Observations at Ipswich, in 1781, 1782 and 1783. Lat. $42^{\circ}38'30''$ N. Long. $70^{\circ}45'$ W. By the Reverend MANASSEH CUTLER, F. A. A. and M. S. and Member of the Philosophical Society at Philadelphia.*

THE thermometer used in the following observations, was made by *Gilbert*, on *Fahrenheit's* scale, with a tube fourteen inches in length. It is placed in an entry-way, remote from fire or the rays of the sun. The barometer is of the portable kind, made by *Hair*. The quantity of rain is measured by an ombrometer, made of tin, twelve inches square at the mouth, the sides of which are perpendicular. The rain falls through the mouth into a funnel, which conducts it into a reservoir, where it is secured from evaporation; and is, afterwards, decanted off and measured in a three-inch cubic measure. It stands firmly secured, in an open situation, with the mouth about two feet from the ground. The quantity of water contained in snows, is generally ascertained by taking the cubic measure of a column of snow, at its mean depth, from the surface to the bottom, and dissolving it in the ombrometer. But as snows frequently fall one upon another, or are accompanied with rain, there is great difficulty in ascertaining, with exactness, the quantity of water that falls during the winter.

In the account of diseases, not every disorder that occurred, but only such as were most prevalent, are inserted. *Edward A. Holyoke*, M. D. favoured me with the account of diseases in *Salem*; *Dr. Isaac Spafford* with those in *Beverly*, and *Dr. Elisha Whitney* with those in *Ipswich*.

Days.

Meteorological Observations for January, 1781. 337

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	8	31	NW.	Fair.	17	8	21		Clouds & ☉ shine.
	1	38	SW.			1	23	NW.	In the evening
	10	40				10	28		Aurora Borealis.
2	8	39	SW.	Fair.	18	8	21		
	1	44				1	27	NW.	Fair.
	10	43				10	28		
3	8	37	N.	Cloudy and snow.	19	8	27		
	1	36				1	35	NW.	Fair.
	10	33				10	34		
4	8	31	SW.	Clouds & ☉ shine.	20	8	27		
	1	35				2	36	N.	Cloudy.
	10	36				10	37		
5	8	39	SW.	Fair, pleasant.	21	8	36		
	1	49	W.			2	39	NE.	Snow; rain; foggy.
	10	42				10	39		
6	8	37	W.	Fair, fine day.	22	8	36		
	1	41	SW.			1	38	NW.	☉ shine; clouds;
	10	42				10	37		fnov.
7	8	40	SW.	Clouds and rain.	23	8	31		
	1	41	N.			2	37	NE.	Snowed; wind very
	9	36				10	30	NW.	high.
8	8	23			24	8	29		
	1	24	NW.	Fair.		2	34	WSW.	Clouds and snow.
	10	23				10	33	W.	About 6 inches of
9	8	18				8	31		fnov on the ground.
	1	23	NW.	Cloudy, fnowed a	25	1	35		
	10	26		little.		10	31	NW.	Fair. Faint Aurora
10	8	33				8	26		Borealis at night.
	1	40	N.	A little fnov, then	26	1	31		
	10	41	SE.	rainy and foggy.		10	32	NW.	Fair, pleasant.
11	8	39			27	8	27		
	1	44	W.	Fair, high wind.		2	32	N.	Cloudy; at night
	10	43				9	36		rain.
12	8	40			28	8	40		
	1	44	W.	Fair.		2	42	SW.	Fair, fine day.
	10	40				10	37	W.	
13	8	36			29	8	32		
	1	37	NW.	Fair.		1	37	SW.	Fair.
	10	35				10	37		
14	8	31			30	8	32		
	1	35	SE.	Snow P. M. & most		1	39	SW.	Rain; fair; high
	10	37		of the night.		10	35	NW.	wind. Faint Au-
15	8	35				8	28		ror a Borealis.
	1	38	W.	Fair. About 5	31	1	31		
	10	33		inches of fnov on		10	31	NW.	Fair. A very faint
	8	26		the ground.					Aurora Borealis.
16	1	31	W.						
	10	27	NW.	Clouds & ☉ shine.					

Therm.	Highest,	40°	49°	43°
	Lowest,	18	23	23
	Mean stat.	32	36	33

The month, in general, open and mild. The frequent small snovs that fell, soon melted. Some days as pleasant as April.

Diseases in *Ipswich*; worm cafes, some fevers, frequent abscesses, cephalalgias, ophthalmias—Healthy.

Diseases in *Salem*; ophthalmias, a few pleurifies and peripneumonys, a few vomitings and purgings, and worm cafes.

Diseases in *Beverly*; pleuritic and peripneumonic fevers, worm cafes, vomitings and purgings.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	8	28	SW.	Cloudy, a little snow.	15	8	39	W.	Fair. At night Aurora Borealis.
	1	33	S.			1	41	NW.	
	10	36				10	43		
2	8	38	SSW.	Rain, foggy.	16	8	41	S.	Clouds; snow; ☉ shine.
	1	40	Calm.			1	38	SE.	
	10	41				10	37		
3	8	41	WNW.	Fair, a very fine day.	17	8	37	W.	Thunder & lightning in the morn. clouds and ☉ shine P. M.
	1	45	W.			1	40	NW.	
	10	37				10	34		
4	8	27	NE.	Mild fn. storm; snow fell 6 inches deep.	18	8	26	NW.	Fair, very cold.
	1	31				1	28		
	10	30				10	29		
5	8	27	W.	Fair A. M. Rain in the evening.	19	8	27	S.	Snow and rain.
	1	35				1	34		
	10	34				10	37		
6	8	31	NW.	Fair.	20	7	34	NW.	Fair.
	1	35				1	32		
	10	32				10	27		
7	8	28	SW.	Very clear.	21	7	23	W.	Fair.
	1	32				1	31		
	10	33				10	32		
8	8	30	SW.	☉ shine and clouds.	22	8	34	E. NW.	Snow & rain; snow fell about 6 inches deep.
	1	35				1	38		
	10	36				11	37		
9	8	23	NW. SW.	Very cold wind. Ther. rem. out of doors, the mercury stood at 0, at $\frac{1}{2}$ after 9 o'clock, A. M.	23	8	35	NE.	Hail and rain.
	1	20				1	37		
	10	21				11	38		
10	8	19	NE.	Severe snow storm; high winds; sno. much drifted, about 16 inches deep.	24	7	36	SW. W.	Fair.
	1	22				1	40		
	10	20				11	39		
11	8	27	NW.	Fine fair day.	25	7	36	SW. W.	Fair.
	1	24				1	40		
	10	23				10	39		
12	8	14	NW.	Fair.	26	7	32	W. NW.	Fair.
	1	23				2	34		
	10	21				10	33		
13	8	19	W. SW.	Fair.	27	7	30	W. SW.	Cloudy.
	1	28				1	36		
	10	32				10	39		
14	8	35	SW.	Fair.	28	8	40	NW.	Fair.
	1	42				1	44		
	10	41				10	38		

	A. M.	Noon.	P. M.
Highest,	41°	45°	43°
Lowest,	14	20	20
Mean stat.	30	34	33

The ground covered with snow during the month.

Diseases in *Ipswich*; some remittent and bilious fevers, pulmonary phthises—Very healthy.
Diseases in *Salem*; ophthalmias, chicken pox, abscesses, a few anginas, pleuritis, hæmoptoes.
Diseases in *Beverly*; slow remittent fevers, abscesses, rheumatism.

Days.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	7	31	N.	☉ shine ; clouds ;	17	7	39	SW.	Fair.
	1	32	SW.	rain.		2	47		
	10	35				10	42		
2	7	34	E.	Clouds ; rain and	18	7	43	NE.	Clouds ; rain ;
	2	37		hail.		2	45		☉ shine.
	10	38				10	43		
3	7	38	SW.	Fair ; wind high.	19	8	40	E.	Rain ; wind high ;
	1	40	W.			2	43	SW.	☉ shine.
	11	38				10	41		
4	7	34	NW.	Fair.	20	7	40	NW.	Fair ; high wind.
	1	38				2	48		
	10	35				10	36		
5	8	31	SW.	Cloudy, snow.	21	7	37	NW.	Fair ; wind high.
	2	38				2	41		
	10	37				10	40		
6	7	39	SW.	☉ shine and clouds.	22	7	36	NW.	Fair.
	1	45				2	40		
	11	43				9	38		
7	8	35	NE.	A N.E. fn.stor. wind	23	7	35	S.	Rain ; snow ;
	1	32		very high ; snow fell		2	37	E.	misty.
	10	29		4 inches deep.		11	42		
8	7	30	NW.	Snow A. M.	24	7	43	W.	Fair.
	1	32		☉ shine and clouds.		2	50	N.	
	11	32				9	44		
9	7	27	NW.	Fair.	25	7	36	NW.	Fair.
	1	36	W.			2	38		
	10	34				9	36		
10	7	31	NW.	Fair.	26	8	35	NW.	Rain ; snow at night,
	1	39	W.			2	41	SW.	fell 2 inches deep.
	10	38				9	39		
11	7	34	NW.	Fair.	27	7	36	NW.	Fair. Aur. Bor. at night ;
	1	42				2	39		a bri. glade of light from
	10	43				9	37		s.e. to n.w. across hemif.
12	7	39	W.	Fair.	28	7	30	SE.	Snow & rain ; wind
	1	46	SW.			1	32	N.	excessive high.
	11	42				9	33		
13	7	37	NW.	Fair.	29	7	32	N.	Squally, ☉ shine.
	2	41				1	35		At night a faint
	10	37				10	34		Aurora Borealis.
14	7	31	SE.	Snow and rain.	30	7	31	NW.	Fair.
	1	37				1	30		
	11	39				11	41		
15	7	40	SW.	☉ shine ; rain ,	31	7	36	NW.	Fair.
	1	50	NE.	foggy.		2	43		
	11	47				10	41		
16	7	46	NW.	Fair.					
	1	47							
	11	42							

Ther.	Highest,	A.M.	Noon.	P.M.
	46°	46°	50°	47°
	Lowest,	27	32	29
	Mean stat.	36	40	38

The weather frequently cloudy and blustering, but no very violent storms. Frost nearly out of the ground at the close of the month.

Diseases in Ipswich ; bilious and peripneumonic fevers, palsies, worm cases.
Diseases in Salem ; anginas, pleurifies, cholics, worms.
Diseases in Beverly ; mixed fevers, chronic rheumatisms, worms, anginas.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	6	37	NW.	Fair.	16	7	42	NE.	Fair.
	2	45	N.			2	49		
	9	45				10	44		
2	7	38	NE.	Violent storms of		7	41	NE.	☉ shine and clouds.
	2	40		rain, snow & hail ;		2	46	SW.	
	11	39		high wind.		9	45		
	7	38	N.			7	46		
3	2	40	NE.	Very high wind ;	18	2	50	NW.	Fair.
	9	40		some snow & rain.		9	47		
	7	37	NW.			7	45	SE.	Rain.
4	2	43	W.	Fair.	19	1	47	NE.	
	10	40				9	44		
	7	41	W.	Fair.		7	42		
5	2	52			20	2	43	NE.	Small rain.
	10	50				9	42		
	6	45	N.	Fair.		7	45	N.	☉ shine and
6	1	50	NE.		21	2	49	NE.	clouds.
	10	48				9	47		
	7	45	NE.	Fair.		7	45	N.	☉ shine and clouds ;
7	2	49			22	1	49	SE.	very high wind.
	10	46				10	47		
	7	49	NE.	Small rain.		7	44	W.	☉ shine and clouds.
8	2	48	SW.		23	2	49	SW.	
	10	46				10	46		
	7	41	WNW	Fair ; excessive		7	43	SSE.	Rainy.
9	1	43		high wind.	24	2	49		
	10	42				9	46		
	8	41	SE.	Fair.		7	48	W.	Clouds and ☉ shine.
10	2	50	S.		25	1	51		
	10	46				10	55		
	7	42	NE.	Very rainy.		6	55		
11	2	43			26	2	57	W.	Clouds and ☉ shine.
	10	42				9	56		
	7	42	W.	Fair.		6	52		
12	2	49	SW.		27	1	54	N.	Fair.
	11	45				9	47		
	7	43	NW.	Cloudy.		6	45	N.	Fair.
13	2	45			28	1	58	SW.	
	10	43				10	51		
	8	39	NW.	Fair.		6	48		
14	2	45			29	2	56	SW.	Fair.
	10	42				11	54		
	6	38	NW.	Fair.		6	51		
15	1	46			30	2	52	S.	Cloudy ; foggy ; rain.
	9	48				11	56		

	A.M.	Noon.	P.M.
Therm. { Highest,	55°	58°	56°
Lowest,	37	40	39
Mean stat.	44	48	46

Very blustering and cold the greater part of the month. Vegetation very backward.

Diseases in *Ipswich* ; pleuritic and peripneumonic fevers, bilious disorders—Healthy in general.
Diseases in *Salem* ; pleurifies, peripneumonics, coughs and colds, anginas, pulmonary phthisis, hæmoptoes, worms, a few mild, putrid, ulcerated throats—Sickly for the season.
Diseases in *Beverly* ; pleurifies, peripneumonics, coughs, colds, anginas and hæmoptoes.

Days.

Meteorological Observations for May, 1781.

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Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	6	54		W.	Fair.	17	6	58	29,83	NW.	Rain, thunder and lightning.
	1	60					1	59	90	E.	
	9	65					9	58	87		
2	7	50		SW.	☉ shine & clouds.	18	6	56	90	NE.	☉ shine and clouds.
	1	62					1	62	91		
	9	60					10	57	93		
3	6	57		NW.	Fair.	19	6	54	30,0	SW.	Fair.
	2	60		W.			2	65	29,86		
	10	58					9	62	86		
4	7	50		NW.	Fair. Violent whirl-wind from NW. to SE.	20	6	58	89	W.	☉ shine ; small rain.
	1	55		W.			1	67	54		
	11	51					10	69	46		
5	7	52		SW.	Fair.	21	7	65	55	NW.	Clouds and ☉ shine.
	1	58		E.			2	61	60	NE.	
	10	57					10	66	66		
6	6	53		S.	Fair; wind high.	22	7	59	92	NE.	Clouds and ☉ shine.
	2	62					2	60		SW.	
	9	58					10	56	30,21		
7	6	55		ESE.	Clouds & ☉ shine; high wind.	23	6	56	20	E.	☉ shine and clouds.
	2	58					1	62	16	SE.	
	10	50					9	57	20		
8	7	47		NE.	Very rainy.	24	6	55	20	NE.	☉ shine and clouds.
	2	48					1	61	15		
	11	47					10	53	10		
9	6	45		N.	Excessive rain—a very great quantity fell in 48 hours.	25	6	52	93	NE.	Very rainy.
	1	44					1	52	29,96		
	10	43					10	52	90		
10	6	43		NE.	☉ shine and clouds.	26	6	51	90	W.	Pleasant, fair.
	1	44					1	58	89		
	9	45					10	57	88		
11	6	42		NE.	Fair.	27	6	57	91	SW.	Fair, a very fine day.
	1	54					1	66	86		
	9	52					10	65	90		
12	8	49		NE.	Clouds, small rain.	28	6	61	99	WSW.	Fair.
	1	50					1	77	65		
	9	52					10	71	80		
13	6	49	29,96	NW.	Clouds and ☉ shine.	29	6	67	85	SW.	Clouds and ☉ shine.
	1	54	97				1	81	55		
	9	52	98				10	71	65		
14	6	48	30,08	NW.	Fair.	30	6	68	85	SW.	☉ shine and clouds.
	2	63	29,98	SW.			1	74	67		
	11	58	82				10	68	80		
15	6	58	77	W.	Fair.	31	7	65	95	W.	Fair.
	1	67	51				1	65	30,05		
	10	67	50				10	63			
16	6	60	71	SW.	Clouds and ☉ shine.						
	1	63	69	E.							
	10	62	76								

Therm.	A. M.	Noon.	P. M.
Highest,	68°	77°	71°
Lowest,	42	44	43
Mean stat.	55	57	58

The month, in general, cold and wet. Vegetation very backward—grafs short and thin—Indian corn planted much later than usual.

Diseases in Ipswich; continued and remittent fevers, peripneumonies, rheumatisms, palsies, worm cafes.

Diseases in Salem; convulsions, vomitings and purgings, worms, pleurifies, rheumatisms, several mild dysenteries, abscesses, coughs and hæmoptoes.

Diseases in Beverly; pleurifies, convulsions, worms, rheumatisms.

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	61	30,01			16	6	61	29,73		
	1	64	05	E.	Fair.		2	68	69	NW.	Fair.
	10	61	09				10	64	77		
2	6	61	05				7	65	79	W.	☉ shine ; clouds ;
	1	61	03	N.	☉ shine and clouds.	17	1	69	66	SW.	small rain.
	10	67	01				10	67	72		
3	6	58	05	NW.			6	65	73		
	2	67	29,96	E.	Fair.	18	2	73	52	S.	Cloudy ;
	9	62	30				9	68	50		rain.
4	6	57	12	N.			6	66	41		
	2	63	06	E.	Fair.	19	1	71	27	WSW.	☉ shine ; clouds ; rain ;
	10	59	18				10	66	61		wind very high.
5	6	55	22	SSE.			6	63	72		
	2	64		S.	Fair.	20	1	68	65	NW.	Fair, wind high ;
	10	63					9	66	72		Aurora Borealis.
6	6	59					6	61	88		
	2	67	01	NE.	Cloudy ; foggy.	21	1	70	68	W.	☉ shine and clouds ;
	9	64	29,99				9	67			at night, thunder
7	7	60	90	ENE.	Cold N.E. storm,		6	60	84	NW.	and lightning ; rain.
	1	58	62	NE.	very rainy.	22	2	74		W.	Fair ; cool ; very
	9	54	69				9	72			windy.
8	6	51	60				6	64	57	NW.	
	2	53	65	NE.	Rainy.	23	1	68		W.	Fair, windy.
	10	53	63				10	66			
9	6	53	61				6	62	80	NW.	Fair ; cool air ; very
	1	61	55	W.	Misty.	24	1	70		W.	drying wind.
	10	62	58				10	66	74		
10	7	60	63				7	67	80		
	1	69	54	WNW	☉ shine, clouds,	25	1	74		SW.	Fair ; clouds ; thun-
	9	65	64		thunder.		10	69	81		der & light. windy.
11	6	63	79				6	64			
	2	72	65	NW.	Fair.	26	1	69		SW.	☉ shine ; clouds ;
	10	60	71				10	66	90	NE.	small rain.
12	6	63	81				7	63	82		
	1	75	59	SW.	Fair.	27	2	63	80	NE.	Very rainy, wind
	9	73	53				9	60	85		high.
13	6	68	58				6	58	84		
	2	76	30	SW.	☉ shine and clouds.	28	1	60	82	N.	Misty.
	9	73					10	60	82		
14	6	69	50				6	60	82		
	1	77	49	SW.	☉ shine and clouds ;	29	2	69	70	SE.	Misty ;
	10	73	44		very sultry.		10	69	72	SW.	small rain.
15	6	70	51				6	67	78		
	2	67	51	N.	Small rain.	30	2	77	62	SW.	Fair ; a very fine
	10	66	56				10	69	81		day.

Therm. { A.M. Noon. P.M.
 Highest, 70° 77° 73°
 Lowest, 51 53 53
 Mean stat. 62 68 62

Barom. { A.M. Noon. P.M.
 30, 22 30, 06 30, 18
 29, 41 29, 27 29, 44
 29, 78 29, 69 29, 76

Plentiful rains. Grain, in general, very fine. Indian corn low for the season.—Very little thunder and lightning.

Diseases in *Ipswich* ; pleurifies, peripneumonies, worms, abscesses, rheumatisms.

Diseases in *Salem* ; fevers, diarrhæas, vomitings with purgings, pleurifies, ophthalmias, abscesses, rheumatisms.

Diseases in *Beverly* ; much the same as in *Salem*.

Days.

Meteorological Observations for July, 1781.

343

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	72	29,76	NE.	Fair, a fine day.	17	7	70	29,60	NNW.	Mist and rain.
	1	75	70	SW.			1	70	52	N.	
	10	72	77				10	69	53		
2	6	69	84	W.	☉ shine; P. M. a thunder shower.	18	7	70	56	W.	Fair, fine day.
	1	77	60				2	81	36		
	9	72	70				9	78	41		
	6	68	80	NW.	Fair.	19	7	69	67	NE.	Very rainy.
3	1	76	62	SW.			1	68	66		
	10	70	76				9	65	71		
	6	69	82				7	63	83	NW.	Fair.
4	1	79	62	NNW.	☉ shine and clouds; brisk air.	20	2	70	72	SE.	
	9	72	91				9	77	85		
	7	68	30,00	NW.	Fair, sultry.	21	7	66	90	SE.	Fair.
5	1	81	29,70	W.			2	73	74		
	9	79	64				9	70	86		
	6	75	85				7	66	95	WNW.	☉ shine and clouds.
6	1	74	85	N.	Smoky, cool breeze.	22	3	75	76	S.	
	9	69	90				10	71	81		
	6	67	90				6	68	84		
7	1	81	58	W.	Fair, smoky and sultry.	23	1	79	50	W.	☉ shine and clouds.
	9	80	52				10	74	58		
	6	76	59				6	70	61	SSW.	☉ shine and clouds; a small sprinkling of rain.
8	1	86	28	WSW.	Hazy, very sultry.	24	2	81	26	S.	
	10	82	19				10	73	40		
	6	79	28				6	71	48		
9	1	83	19	NW.	Fair.	25	1	75	45	WNW.	Cloudy, smoky air.
	10	78	45				10	73	53		
	6	74	72				7	69	72	NW.	☉ shine and clouds.
10				NNE.	☉ shine and clouds; cool air.	26	2	74	62	W.	
	10	66	95				10	69	80		
	6	67	96				6	69	90		
11	2	69	97	NNE.	Misty morn; ☉ shine; cool air.	27	2	74	80	N.	☉ shine and clouds.
	10	66	30,05				10	70	82		
	7	65	06	NNW	☉ shine and clouds.	28	6	67	88	W.	☉ shine and clouds.
12	2	70		NE.			2	77	62	S.	
	10	66	00				10	72	71		
	7	65	29,96				7	68	78		
13	1	76	68	SSW.	Fair, very sultry and dry.	29	1	74	64	SW.	Fair morn, cloudy afternoon.
	9	76	76				10	73	61		
	6	70	82				6	72	60		
14	1	80	51	W.	Cloudy; high wind.	30	1	80	44	W.	☉ shine & clouds. P.M. a plentiful show. of ra. without thun. or ligh.
	10	76	54	SW.			10	75	46		
	6	76	50				6	72	54	WNW	☉ shine and clouds.
15	1	75	24	SW.	Plentiful rain.	31	2	79	36	W.	
	10	74	59	N.			10	75	41		
	7	73	62								
16	1	74	56	N.	Hazy.						
	10	70	62								

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.
Hig.	79°	86°	82°	30,06	29,97	30,05
Low.	63	68	65	29,28	29,19	29,19
M. stat.	70	76	72	29,75	29,57	29,68

The first part of the month very hot and dry; the hot weather continued with repeated rains and great dews. English grain, in general, very fine. Rye considerably injured by blast or mildew. Siberian wheat, which was sowed in large quantities, almost totally ruined. English hay, plenty. Indian corn, and flax, very good. Scarce any thunder and lightning.

Diseases in Ipswich; bilious complaints, anasarca, worm cases, a few fevers—Very healthy.

Diseases in Salem; diarrhæas vomitings, dysenteries, anasarca, ophthalmias.

Diseases in Beverly; alvine fluxes, remittent and putrid fevers.

Days

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	71	29,56	NNE.	Fair; very smoky	17	7	61	30,14	W.	Clouds and ☉ shine.
	1	74	53	NE.	P. M.		2	68	00	SW.	
	9	71	68				9	67	00		
2	7	70	70	NNE.	Fair, smoky.	18	7	65	06	SW.	☉ shine.
	1	75	63	SE.			1	71	29,93	E.	
	9	69	81				10	67	30,00		
3	7	65	90	E.	Foggy morn; fair;	19	6	66	29,93	E.	☉ shine and clouds,
	1	74	70	SE.	at night rain.		1	73	73		rain afternoon.
	9	70	80				9	70	72		
4	7	70	80	SE.	☉ shine and clouds,	20	7	69	50	NNW.	Fair. Aur. Borealis
	1	77	65	SW.	fultry.		2	75	44		which continued
	10	76	68				9	70	70		thro' the night.
5	7	72	84	WNW.	☉ shine and clouds.	21	6	65	90	WNW.	Very clear. Aurora
	2	80	60	SW.			2	74	70		Borealis at night:
	10	74	75				9	71	72		
6	6	74	74	NW.	Fair; very fultry. A	22	7	67	91	SW.	Fair. Aur. Borealis
	1	82	51	SW.	very curious Aur.		2	78	60		at night.
	10	78	50		Borealis at night.		10	72	74		
7	6	74	57	SW.	Fair, still very fultry.	23	1	71	79	S.	Cloudy.
	2	82	36				2	75	59		
	10	79	85				10	73	62		
8	7	76	85	W.	Fair; ther. outdoors,	24	7	72	70	NNW.	Clouds and ☉ shine.
	2	87	06	SW.	and in the sun, merc.		1	74	65		
	10	83	11		rang. at 108° at 5 P.M.		10	70	84		
9	6	75	39	W.	Fair, brisk air.	25	7	65	96	N.	Clouds and ☉ shine.
	2	80		SW.			1	69	88		
	10	77	41				9	65	95		
10	7	71	65		Fair; brisk wind;	26	6	64	94	NNW.	☉ shine, clouds,
	1	72	62	NW.	cool; a very sudden		2	68	76		rain at night.
	9	69	90		change in the weather		9	68	72		
11	7	64	30,05	N.	Wind brisk; ☉ shine	27	6	78	62	WNW.	Foggy morn; ☉ shine;
	1	67	02	NW.	and clouds.		2	72	56	N.	shower at night.
	10	65	04				9	69	69		
12	7	61	38	E.	Cool, very smoky,	28	6	62	86	NW.	Fair.
	1	70		NE.	clouds and ☉ shine.		1	73		SW.	
	9	67	29,84				9	68	74		
13	7	69	46	SW.	Plentiful rain last	29	6	68	69	SW.	Clouds and ☉ shine.
	1	71	43	W.	night & this morn;		1	72			
	10	69	52		clouds and ☉ shine.		9	71	78		
14	6	65	73		☉ shine; Aurora	30	7	69	30,07	SW.	Clouds and ☉ shine.
	1	60	72	NW.	Borealis at night.		1	72	29,80		
	10	64	90				10	71	77		
15	7	62	30,06	NNW.	Fair.	31	6	71	69	S.	Clouds; plentiful
	1	69	29,95				1	76	50		shower.
	9	67	30,07				10	69	73		
16	6	62	14	E.	Foggy morn. ☉ shine						
	2	70	02	SE.							
	10	65	10								

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.
Hig.	76°	87°	83°	30,14	30,02	30,10
Low.	61	67	64	29,39	29,06	29,11
M. stat.	68	74	70	29,81	29,66	29,67

The air frequently much loaded with vapour. Not an instance of thunder and lightning. Salt grass well grown. Garden esculents very plenty.

Diseases in *Ipswich*; diarrhæas dysenteries, cardialgias, anginas—Healthy.

Diseases in *Salem*; vomitings and purgings, coughs, abscesses, fevers, choleras, abortions.

Diseases in *Beverly*; putrid fevers, diarrhæas, and dysenteries.

Meteorological Observations for September, 1781.

345

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	6	63	29,93			16	7	63	29,77		
	2	69	82	WNW	Fair.		1	77	40	W.	☉ shine; clouds; windy; rain at night.
	9	66	90				10	74	47		
	6	61	95	WNW			6	66	82	NE.	
2	1	68	72	SW.	☉ shine and clouds.	17	1	61	98	E.	☉ shine and clouds.
	10	68	64				10	56	30,03		
	6	66	69				7	58	29,93	E.	Very rainy, with high wind; fair; bright Au.
3	1	76	44	SW.	☉ shine and clouds.	18	1	60	70	W.	Borealis at night.
	9	72	45				9	61	62		
	7	73	40	SW.	☉ shine; cloudy; small rain.		6	58	72	W.	
4	2	81	25	NW.		19	2	71	48	SW.	Very clear.
	9	72	62				10	70	50		
	6	65	30,00				6	67	63	NW.	
5	1	70		NW.	☉ shine and clouds.	20	1	59	96	NNW.	Cloudy, a little rain.
	9	63	27				9	57	30,01		
	7	59	34	NW.	☉ shine and clouds.		7	55	04	NW.	Cloudy, rain, fair.
6	1	67	15	W.		21	1	54	29,99	N.	
	9	65	10				10	51	30,07		
	7	65	00	S.	☉ shine; clouds; rain at night with high wind.		6	47	21		
7	1	74	29,55	SW.		22	2	53	13	NW.	Very small frost in the morn. ☉ shine and clouds; windy.
	11	73	42				10	54	20		
	7	70	58	WNW			7	50	25		
8	1	66	80	NW.	Fair, windy.	23	2	63	29,93	W.	Fair.
	10	61	30,14				9	63	94		
	8	58	14				6	57	30,10		
9	2	64	20	NW.	Clear.	24	1	68	29,91	WNW.	Fair.
	9	62	28				9	63	30,00		
	7	61	25				6	59	01		
10	2	65	09	SW.	Fair.	25	2	74	29,50	SW.	Fair, fine day. Aur. Borealis at night.
	9	62	07				9	70	60		
	7	62	29,92				6	64	67		
11	1	69	60	SSW.	Clouds, rain.	26	1	62	71	WNW.	Fair, wind very high.
	10	69	42				9	57	94		
	7	63	69				7	52	98	NW.	☉ shine and clouds; rain at night.
12	1	64	70	SW.	Clouds, ☉ shine.	27	1	58	81	WSW.	
	9	62	83				10	57	66		
	7	60	93				7	56	61		
13	2	66	82	W.	☉ shine and clouds.	28	1	65	47	NW.	Fair, fine day.
	10	62	92	E.			10	60	65		
	7	57	30,07				7	55	74	NNW.	☉ shine and clouds.
14	1	69	29,92	W.	Fair.	29	2	60	60	NE.	
	10	65	30,05				9	60	54		
	7	62	08				7	58	59	WNW.	☉ shine and clouds.
15	1	74	29,76	W.	Fair.	30	2	58	74	NNW.	
	10	69	80				9	55	30,03		

	A.M.	Noon.	P.M.
Therm.	Highest, 73°	77°	77°
	Lowest, 47	53	51
	Mean stat. 60	66	63

	A.M.	Noon.	P.M.
Barom.	30, 34	30, 20	30, 20
	29, 40	29, 25	29, 48
	29, 90	29, 76	29, 84

Very little rain. Fine weather for ripening Indian corn, and making salt hay, of which there are good crops. Garden-fruit plenty.

Diseases in Ipswich; diarrhoeas, dysenteries, vomitings—Very healthy.
Diseases in Salem; dysenteries, vomitings and purgings, choleras, abscesses, diarrhoeas.
Diseases in Beverly; dysenteries and diarrhoeas, low fevers.

U u

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	48	30,26	NNW.	Fair; a small frost this morning.	17	7	57	29,80	WSW.	Rainy morning, fair.
	2	54	20	SW.			1	51	87	W.	
	10	52	20				10	51	94		
2	8	55	24	SE.	☉ shine and clouds; rain at night.	18	7	46	30,01	NNE.	Clouds; rain P.M. & thunder at night.
	2	61	29,98				1	52	29,96	NE.	
	9	60	92				10	51	30,00		
3	7	59	90	NW.	Foggy; fair; shower at 5 o'clock.	19	7	49	07	NW.	Clouds and ☉ shine.
	1	62	83				2	51	03	NE.	Faint Aur. Bor. at nig.
	9	58	30,00				11	46	13		
4	7	49	31	NW.	☉ shine and clouds.	20	7	44	06	SW.	☉ shine & clouds; at night thun. & light.
	2	50	40				2	50	29,73		
	9	48	55				10	56	59		
5	7	40	68	W.	Fair. Water a little frozen this morn.	21	7	54	57	WSW.	☉ shine and clouds, fine day.
	1	49	45	SW.			2	56	48		
	10	52	30				10	54	66		
6	7	51	25	W.	Fair.	22	8	51	95	NW.	☉ shine and clouds.
	2	60	29,98				1	53	96		
	9	55	30,06				10	50	30,19		
7	7	53	24	N.	Clouds and brisk wind.	23	7	44	37	NW.	☉ shine and clouds.
	1	53	36				1	48	29	E.	
	9	51	46				10	48	27		
8	8	43	58	NNW.	Fair. Small Aur. Borealis at night.	24	7	49	06	SSW.	Clouds, rain aftern.
	2	53	38	SW.			1	57	29,67	WNW.	
	10	48	28				10	54	61		
9	7	46	14	NW.	Fair.	25	7	46	94	WNW.	Fair, fine day.
	1	59	29,90				2	49	94		
	10	59	97				10	45	30,14		
10	7	52	30,06	W.	Fair.	26	7	44	14	N.	Clouds, rainy aftern.
	1	63	29,80	SW.			2	48	05	NE.	
	9	66	76				10	51	29,92		
11	7	61		W.	Fair.	27	7	49	30,10	NNW.	Clouds and ☉ shine.
	2	70		SW.			2	54	13		
	9	68	74				10	50	32		
12	8	63	80	SW.	Several showers; some thun. & ligh.	28	7	46	46	N.	Clouds and ☉ shine.
	2	72	55				2	49	40		
	9	69	52				8	47	36		
13	7	63	49	SW.	☉ shine, clouds; rain P.M. with thun. and ligh. & high wind.	29	7	45	22	NW.	Moderate rain.
	2	69	17	W.			2	48	00	N.	
	9	67	20				9	45	29,95		
14	7	50	65	WNW.	Clouds and ☉ shine.	30	8	42	92	W.	Fair, brisk wind.
	1	54	72				1	47	82		
	9	59	82				10	45	93		
15	7	56	95	SW.	Fair; at night a very curious Aur. Bor.	31	7	40	30,02	SW.	Fair, fine day.
	2	69	83				2	57	29,87		
	11	61	30,00				9	52	94		
16	7	60	00	SW.	☉ shine and clouds; very brisk wind.						
	1	68	29,75								
	10	65	63								

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.
Hig.	63°	72°	69°	30,68	30,45	30,55
Low.	40	47	45	29,49	29,17	29,20
M. stat.	50	56	54	30,01	29,93	29,97

More thunder and lightning in this month than during the whole summer. Several frosts; but many of the more hardy flowers still remain uninjured. Garden esculents plenty. Indian corn well ripened, and a good crop.

Diseases in *Ipswich*; a very few dysenteries and diarrhoeas, low fevers—Very healthy.

Diseases in *Salem*; dysenteries, vomitings and purgings, choleras, abscesses, diarrhoeas, fevers, abortions.

Diseases in *Beverly*; bilious cholics, some nervous fevers.

Meteorological Observations for November, 1781.

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Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	48	30,04		Cloudy ; very great	16	8	35	30,40		Fair, Aur. Borealis
	2	51	29,93	N.	quantity of rain at		2	41	32	WNW.	at night.
	10	53	66		night ; wind high.		10	40	33		
2	7	52	55	SW.	Misty ; at night	17	8	37	33	SSE.	☉ shine and clouds.
	1	54	60	E.	very rainy.		1	40	23	NE.	
	9	53	70				9	41	07		
3	8	50	60		Very rainy, high	18	8	42	29,90	N.	Clouds and ☉ shine.
	1	49	51	N.	wind.		1	42	92	NW.	
	10	48	60				9	42	30,03		
4	7	45	63		Cloudy.		8	39	07	W.	Fair. Small Aurora
	1	46	62	NW.		19	2	44	29,95	WSW.	Borealis at night.
	9	46	71				11	44	30,07		
5	7	41	73		Blustering & squally.		8	35	26		
	1	40	71	NW.		20	1	36	28	NW.	☉ shine and clouds.
	10	40	72				10	35	50		
6	7	39	74		Cloudy & blustering.		8	30	55	NW.	Cloudy ; at night
	2	43	71	NW.		21	2	35	36	NE.	fnow, which fell about
	10	44	75				9	35	21		6 inches deep.
7	9	46	72		Fair and very plea-	22	8	32	29,92	NW.	Clouds and ☉ shine.
	1	47	62	NW.	fant.		1	34	86	WSW.	
	10	44	84				10	34	86		
8	7	40	8	W.	Very blustering and		8	32	30,16		Fair.
	1	43	70	NW.	squally.	23	2	32	30	W.	
	10	40	86				10	29	58		
9	9	35	97		Very chilly and		9	23	84	NW.	Fair.
	1	36	92	NW.	blustering.	24	2	29	80		
	9	33	92				10	29	80		
10	8	31	30,04		Fair, windy and	25	8	27	70	SW.	Cloudy ; very rainy
	1	36	02	NW.	chilly.		1	33	48		night.
	10	37	10				9	40	07		
11	8	33	12		Fair.		8	40	29,33	SSE.	Cloudy, rain.
	1	35	10	NW.		26	2	45	40	NW.	
	9	37	03				10	35	30,02		
12	8	35			Stormy.		8	26	26		
	1	40	29,83	NE.		27	1	30	36	NW.	Fair, brisk wind.
	10	40	79				11	32	50		
13	9	38	83		Cloudy and very		8	26	62	N.	Cloudy ; wind high ;
	1	40	93	NNE.	chilly.	28	1	33	52	NE.	at night very
	10	39					11	37	23		rainy.
14	8	38	30,7		Cloudy.		8	43	29,50	E.	Rainy & blustering.
	2	39	10	NNE.		29	2	43	41	NW.	
	10	39	12				11	37	67		
15	8	37	17		Cloudy.		8	34	96		Fair and pleasant.
	2	40	10	NW.		30	1	39	30,06	W.	
	11	37	30				10	38	22		

	A. M.	Noon.	P. M.		A. M.	Noon.	P. M.
Therm.	Highest,	52°	54°	53°	Barom.	30,84	30,80
	Lowest,	23	29	29		29,33	29,40
	Mean stat.	37	40	39		30,03	29,99
							30,01

The greater part of this month very windy, cold and stormy.

Diseases in Ipswich ; some low fevers, coughs and colds.

Diseases in Salem ; pleurifies, abscesses, anasarcas, coughs, ophthalmias.

Diseases in Beverly ; cholics, coughs, some febrile complaints—Healthy.

U u 2

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	36	30,30	NNW.	☉ shine and clouds.	17	8	21	30,30	NW.	☉ shine and clouds.
	2	41	23	NE.			2	26			
	10	41	25				9	31	40		
	8	38	20				8	29	47	NNW.	☉ shine and clouds.
2	1	40	14	NNW.	☉ shine and clouds, very blustering.	18	2	30	67	NW.	☉ shine and clouds.
	10	39	25				9	27	70		
	9	37	17				9	20	74	W.	
3	1	37	14	NNW.	Sprinkling of snow, and then rain.	19	2	31	57	S.	Clouds and ☉ shine.
	10	38	20				10	33	47		
	8	34	33				8	37	29,81	SE.	Fog and mist.
4	2	41	28	WNW.	☉ shine and clouds.	20	1	41	50	NW.	Most of the snow gone at night.
	10	40	21				11	40	80		
	8	40	29,73	NE.	Very severe storm of rain, with high wind.		9	31	30,35	NW.	Fair.
5	2	41	41	NW.		21	1	30	50		
	11	38	62				11	28	72		
	8	35	82				8	24	70	W.	
6	1	36	82	W.	☉ shine & clouds.	22	1	27	60	SW.	Fair.
	11	38	80				10	30	50		
	9	37	70				8	28	48		
7	1	38	64	N.	A sprinkling of snow last night.	23	1	35	41	NW.	Fair.
	11	38	80	NW.			9	36	52		
	8	33	30,03				8	28	69		
8	2	34	03	W.	☉ shine & clouds.	24	2	27	66	N.	Cloudy & blustering.
	11	37	23				9	24	62		
	8	31	26				8	22	70		
9	1	34	17	W.	☉ shine and clouds; snow at night.	25	2	26	69	NW.	Fair.
	10	36	04				11	24	78		
	8	36	29,46	NNE.			8	21	78	WNW.	
10	1	35	30	W.	Snow, rain & hail.	26	1	26	64	W.	Fair.
	10	31	55				11	32	45		
	8	27	72				9	30	30		
11	2	32	68	WSW.	Fair. Aurora Borealis at night.	27	1	32	20	SW.	Cloudy and misty.
	11	30	74				10	36	04		
	8	27	68				8	35	29,80	N.	
12	2	30	60	SW.	☉ shine and clouds.	28	2	38	24	NE.	Very rainy.
	11	31	70				11	37	60		
	8	29	72				8	35	82	S.	
13	2	34	70	SW.	Fair and pleasant.	29	2	38	40	W.	Small quantity of snow.
	9	37	80				10	38	40		
	8	31	95				8	34	30,20		
14	1	34	91	SW.	Fair, pleasant.	30	1	37	26	WNW.	Fair and pleasant.
	10	33	96				10	35	44		
	8	27	98				8	32	40		
15	2	31	90	W.	Fair.	31	2	36	10	NNW.	Snow and rain; foggy at night.
	10	30	30,00				11	38	29,73	SE.	
	8	22	18	WNW.	Clouds, sprinkling of snow at night.						
16	2	26		N.							
	10	29	11								

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.
Hig.	40°	41°	40°	30,78	30,69	30,78
Low.	20	26	24	29,46	29,24	29,40
M. stat.	30	34	34	30,15	30,01	30,11

The ground covered with a small quantity of snow during the month; but not more than three or four inches deep at any one time.

Diseases in Ipswich; colds, abscesses, coughs, pulmonary consumptions.

Diseases in Salem; pleurifies, catarrhal fevers, anginas, abscesses, coughs, cholera, anasarca,

Diseases in Beverly; chronic rheumatisms, bilious cholera.

Thermometer.

1781.	Thermometer.			Barometer.		
	Greatest Height.	Least Height.	Mean Height.	Greatest Height.	Least Height.	Mean Height.
January,	49	18	34			
February,	45	14	32			
March,	50	24	38			
April,	58	37	46			
May,	77	42	57			
June,	77	51	64	30, 22	29, 27	29, 74
July,	86	63	73	30, 06	29, 19	29, 67
August,	87	61	71	30, 15	29, 06	29, 74
September,	77	47	69	30, 34	29, 25	29, 83
October,	72	40	53	30, 68	29, 17	29, 97
November,	54	23	39	30, 84	29, 33	30, 01
December,	41	20	33	30, 78	29, 24	30, 09
Whole Year,	87	14	51			

1782.

JANUARY.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Highest,	44	45	44	30, 88	30, 87	30, 83
Lowest,	6	10	7	29, 92	29, 90	29, 92
Mean stat.	26	28	25	30, 37	30, 36	30, 39

The weather variable---frequent snows and rains. Predominant winds from W. to N. E. The mercury in the barometer ranged exceeding high. On the 23d, a severe snow-storm, in which the snow fell twenty inches deep---wind N. E. The two last days intensely cold. Forty-four inches of snow fell during the month---the ground constantly covered. Fourteen days of falling weather.

Greatest degree of heat on the 4th, at 1, P. M.---barom. at 30, 25---wind W.---fair. Greatest deg. of cold on the 31st, at 8, A. M.---barom. at 30, 87---wind S. W.---fair. Barom. highest on the 2d, at 8, A. M.---therm. 24°---wind N.---fair: lowest on the 25th, at 2, P. M.---therm. at 22°---wind S.S.W. ---fair.

In

In the evening of the 2d, a faint Aurora Borealis----wind S. W.---snowed the preceding day in the morn.---the following rainy. Another in the night of the 9th---wind N. W.---preceding day misty---snowed on the four following days.

Diseases in *Ipswich* ; rheumatisms, palsies, coughs, ophthalmias : In *Salem* ; cholics, catarrhal fevers, ophthalmias, coughs and defluctionary disorders : In *Beverly* ; worms, peripneumonies and other pulmonic disorders.

FEBRUARY.

	Therm.				Barom.		
	A. M.	Noon.	P. M.		Noon.	P. M.	
Highest,	37	40	39	30, 99	30, 93	30, 83	
Lowest,	6	15	18	29, 84	29, 62	29, 90	
Mean stat.	27	30	30	30, 38	30, 32	30, 33	

Blustering, stormy and cold----few pleasant days----ground covered with a considerable depth of snow. Predominant winds from W. to N. E. Eight days of falling weather. Fifteen inches of snow fell during the month.

Greatest deg. of heat on the 22d, at 2, P. M.----barom. at the lowest---wind S. W.---cloudy. Greatest deg. of cold on the 1st, at 8, A. M.---barom. highest---wind N. W.---fair.

An Aurora Borealis in the evening of the 6th---wind N.---the preceding and following days fair ; but on the third and fourth days after, it snowed.

Diseases in *Ipswich* ; worm cases, pleurifies—Very healthy : In *Salem* ; cholics, anginas, pleurifies, rheumatisms, scrophulas : In *Beverly* ; pulmonic diseases, small pox.

MARCH.

	Therm.				Barom.		
	A. M.	Noon.	P. M.		Noon.	P. M.	
Highest,	43	50	44	30, 68	30, 70	30, 60	
Lowest.	21	31	33	29, 66	29, 63	29, 43	
Mean stat.	35	40	37	30, 09	29, 99	30, 09	

The

The weather, in general, mild. Predominant winds from S. W. to N. Small quantity of snow with rain fell on the 11th. The ground mostly bare by the middle of the month. The latter part of the month windy. Six rainy days, in which a large quantity of rain fell; but no severe storm. Grain appears to have been very little injured by the winter.

Greatest deg. of heat on the 14th, at 1, P. M.---barom. 30, 02---wind S. W.---sunshine and clouds. Greatest deg. of cold on the 4th, at 7, A. M.---barom. at 30, 58---wind N. W.---fair. Barom. highest on the 8th, at 2, P. M.---therm. at 38°---wind N. E.---cloudy: lowest on the 27th, at 9, P. M.---therm. at 42°---wind high at S. W.---cloudy.

A faint Aurora Borealis on the 9th at night---wind W.---preceding day fair---on the following, rain and snow. On the 14th, a bright parhelion, south of the sun, at 7, A. M. In the morning of the 18th, very severe thunder---two houses, a barn and many trees struck with the lightning in this town.

Diseases in *Ipswich*; cholera morbus, pulmonary consumptions, rheumatisms, colds, coughs, ophthalmias, scrophulas: In *Salem*; ophthalmias, scrophulas, bad coughs: In *Beverly*; remitting fevers.

APRIL.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Highest,	56	68	62	30, 53	30, 48	30, 50
Lowest,	39	43	41	29, 65	29, 67	29, 66
Mean-stat.	46	52	49	29, 98	30, 01	30, 05

The first part of the month, warm and pleasant. Vegetation advanced with great rapidity. The wind frequently between E. and S. and between S. and W.---though it prevailed mostly between W. and N. But from the 16th to the end

end of the month, the wind was, for the most part, northerly, very high, and frequent cold storms of rain. Twelve days on which rain fell. From the 19th to the 25th, wind constantly N. E. and more or less rain fell every day.

Greatest deg. of heat on the 15th, at 2, P. M.---barom. at 29, 84---wind S.---fair. Greatest deg. of cold on the 11th, at 6, A. M.----barom. 30, 59----wind N. N. E.----cloudy. Barom. highest on the 26th, at 6, A. M.----therm. 43°----wind N. N. W.---cloudy : lowest on the 4th, at 6, A. M.---therm. 51°----wind very high at W. N. W.----clouds and sunshine.

The Aurora Borealis appeared in the night of the 2d,---wind W.---and of the 4th,---wind W. N. W.---the preceding and following days fair.—Wind very high on the 5th and 6th. Another Aurora in the night of the 14th,---wind W. S. W.---preceding and following days fair.

Diseases in *Ipswich* ; putrid and flow fevers, dysenteries, cholics—Sickly : In *Salem* ; chin coughs, cholics, ophthalmias, pleurifies, peripneumonies, rheumatisms, catarrhal fevers—Very sickly : In *Beverly* ; disorders in the first passages, tumors.

MAY.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.
Highest,	61	68	63	30, 32	30, 30	30, 28
Lowest,	47	47	47	29, 28	29, 34	29, 60
Mean stat.	54	59	56	29, 91	29, 90	29, 95

The month very cool and wet---no frost. Prevailing winds from W. to N. and N. E. Vegetation backward. Peach, and some other fruit-trees, injured by the winter. Fourteen days on which rain fell.

Greatest

Greatest deg. of heat on the 12th, at 1, P. M.---barom. 29, 65---wind N.W.---fair. Greatest deg. of cold on the 4th---the mercury ranged at the same height morning, noon and night---barom. rose from 29, 61 to 29, 80---wind N.---clouds and rain. The night was very remarkably light, although it was cloudy and no moon; probably occasioned by a very bright Aurora Borealis. Barom. highest on the 17th, at 1, P. M.---therm. 53°---wind N.E.---fair: lowest on the 10th, at 6, A.M.---therm. 58°---wind N. W.---fair.

An Aurora Borealis in the night of the 5th---wind N.N.W.---of the 6th---wind S. W.---of the 9th---wind S. S. W.---and of the 22d---wind S. W. Rain on the preceding and following days of the four first; fair weather preceding and following the last of them. Thunder and lightning on the 13th.

Diseases in *Ipswich*; convulsions, bilious cholics, putrid fevers, worms: In *Salem*; chin coughs, cholics, catarrhal fevers, convulsions—Sickly: In *Beverly*; pulmonic fevers, worms.

JUNE.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Highest,	80	88	81	30, 43	30, 31	30, 39
Lowest,	54	62	56	29, 27	29, 10	29, 23
Mean stat.	66	75	70	29, 79	29, 62	29, 76

Predominant winds from S. W. to N. W. Frequent mild showers—very little thunder and lightning—only one whole day cloudy during the month. From the 15th to the 24th, extremely sultry. The weather exceedingly favourable to vegetation. All kinds of corn, grass and garden-productions, promise plentiful crops. Little injury done by insects and reptiles.

tiles, except canker-worms on apple-trees ; by which many orchards, for years past, have not only been deprived of fruit, but the trees almost destroyed.*

Greatest deg. of heat on the 22d, at 1, P. M.---barom. 29, 10---wind W. S. W.--- sunshine and clouds. Greatest deg. of cold on the 8th, at 6, A. M.---barom. 30, 36---wind high at S. W.---fair. Barom. highest on the 9th, at 7, A. M.---therm. 50°---wind S. W.---fair :---lowest on the 23d, at 1, P. M.---therm. 71°---wind high at S. S. E.---heavy shower of rain.

Northern lights in the evenings of the 5th and 6th---wind W. N. W.---on the 3d and 4th, showers of rain---the six following days fair. Distant lightning on the 6th---thunder and lightning on the 19th, 22d and 23d.

Diseases in *Ipswich* ; slow fevers, worms, rheumatisms, pleurifies, pulmonary consumptions : In *Salem* ; chin coughs, and

* Among the many experiments that have been made for destroying canker-worms, tarring round the body of the trees seems to have been the most effectual : but if the tar be applied on the bark, it will injure the trees, especially if they are young, nearly as much as the worms. This injury, however, may be entirely prevented, and the worms more effectually destroyed, by putting, next the bark, a clay mortar well mixed with hair or chopped straw, about an inch thick ; upon the mortar a strip of canvass or birch bark : then take a large rope of swingled tow, twisted by hand, and make two or three turns round the tree, below and close to the canvass, drawing it tight upon the moist mortar to prevent the tar from running down. Let the canvass be tarred every day, just before sunset, from the time the snow is gone under the trees, in the spring, until no worms are found on the tar. When the worms have done passing, the whole is to be removed from the trees. By this method much less tar is used, and it has been found, by repeated experiments, that the worms will be destroyed in two years without the least injury to the trees. But compleat success is not to be expected, unless the trees are tarred as soon as the snow, if it lays late in the spring, is melted away about their bodies, and faithfully continued, every day, until the worms have done passing.

and vomitings and purgings among children: In *Beverly*; chronic disorders.

JULY.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Highest,	79	84	80	30, 05	29, 81	30, 00
Lowest,	61	68	60	29, 21	29, 06	29, 15
Mean stat.	69	71	66	29, 64	29, 42	29, 57

The whole of the month, especially the latter part, very dry. A few small showers of rain. Frequent heavy fogs, and cool nights. Winds principally from W. to N. Siberian wheat entirely destroyed by a blast or mildew---rye in general shared the same fate---oats and barley greatly injured---Indian corn, and the later garden esculents suffered from the drought and cold---plentiful crops of English hay.

Greatest deg. of heat on the 15th, at 2, P. M.---barom. lowest---wind S. W.---sunshine and clouds. Greatest deg. of cold on the 20th, at 9, P. M.---barom. 29, 61---wind S. W.---fair. Barom. highest on the 20th, at 8, A. M.---therm. 68°---wind S. W.---cloudy.

Northern light in the evening of the 9th---wind S. W.---the preceding night rain---the following days fair and cool: also, in the evening of the 20th---wind S. W.---preceding days fair---the third day after, rain. Thunder and lightning on the 24th.

Diseases in *Ipswich*; diarrhæas, pleuritic fevers: In *Salem*, putrid fevers, cholics, vomiting blood, chin cough, choleras, vomiting and purging among children: In *Beverly*; worm fevers.

AUGUST.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.
Highest,	79	85	76	30, 30	30, 12	30, 22
Lowest,	55	66	61	29, 26	29, 20	29, 37
Mean stat.	67	73	69	29, 82	29, 65	29, 85

Very dry---small showers of rain on the 3d, 10th, 13th, 19th and 26th. Foggy nights and mornings from the 18th to the 27th. Winds very variable---prevailed mostly from W. to N. Indian corn and garden vegetables suffered by the drought. Pastures exceedingly dried up. Salt grass very good.

Greatest deg. of heat on the 9th, at 2, P. M.---barom. lowest---wind S. W.---fair. Greatest deg. of cold on the 13th, at 7, A. M.---barom. highest---wind W.---fair.

Faint northern lights in the evenings of the 26th and 28th, ---wind N. W.---fair and cool after them. On the 9th, a few claps of thunder, with lightning.

Diseases in *Ipswich*; dysenteries, slow fevers, worm cases: In *Salem*; cholera morbus, chin coughs, mild dysenteries, vomiting and purging among children: In *Beverly*; cholera morbus.

SEPTEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.	
Highest,	74	86	78	30, 40	30, 22	30, 25	Rain.
Lowest,	47	56	51	29, 51	28, 97	29, 56	Inch.
Mean stat.	59	67	59	30, 02	29, 80	29, 95	0,703

Winds variable, and frequently very high---prevailed mostly between S. and N. W. The drought extremely severe---only four very small showers during the month. The dews were commonly large, and preserved the verdure of some kinds of vegetables. In the latter part of the month, the atmosphere constantly

Frequent mild rains. Predominant winds from S. W. to N. W. In the night of the 5th, water froze abroad. On the 17th and 18th, wind excessive high, with rain and hail. Fifteen days on which rain fell.

Greatest deg. of heat on the 3d, at 1, P. M.---barom. 29, 75---wind W.---fair. Greatest deg. of cold on the 5th, at 7, A. M.---wind E. N. E.---cloudy. Barom. highest on the 28th, at 7, A. M.---therm. 43°---wind N. W.---fair: lowest on the 6th, at 1, P. M.---therm. 63°---wind N. W.---fair.

Frequent northern lights in the first part of the month---wind between S. W. and N. W.---rain within two or three days after each of them.

Diseases in *Ipswich*; chin coughs, continued and putrid fevers, worms: In *Salem*; dysenteries, rheumatisms, flow fevers, mumps: In *Beverly*; flow fevers.

NOVEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Highest,	51	55	54	30, 88	30, 85	30, 76	Rain.
Lowest,	22	24	27	29, 51	29, 55	29, 50	Inch.
Mean stat.	37	41	41	30, 15	30, 12	30, 09	4,533

Predominant winds from S. W. to N. W. Frequently cloudy. A storm of snow on the 21st---wind N.---snow fell four and an half inches deep. The ground very little froze, and the snow melted in a few days. Nine days of falling weather.

Greatest deg. of heat on the 7th, at 2, P. M.---therm. lowest---wind S. W.---cloudy. Greatest deg. of cold on the 29th, at 8, A. M.---barom. 30, 60---wind W.---fair. Barom. highest on the 10th, at 8, A. M.---therm. 33°---wind N.---fair.

The

The Aurora Borealis appeared only in the evening of the 26th---wind W. N. W.---cold and windy after it.

Diseases in *Ipswich*; rheumatisms, cholics: In *Salem*; flow fevers, rheumatisms, erysipelas, mumps, cholics: In *Beverly*; hæmoptoes, worms.

DECEMBER.

	Therm.				Barom.			
	A.M.	Noon.	P.M.		A.M.	Noon.	P.M.	
Highest,	50	53	50	30, 75	30, 71	30, 83		Rain.
Lowest,	17	21	14	29, 37	29, 50	29, 56		Inch.
Mean stat.	35	37	34	30, 15	30, 09	30, 15		3,601

The weather, in general, pleasant; the air, on many days, as pleasant as in April or May. Prevailing winds from S. W. to N. W. The ground bare and very little froze. Snow fell three inches deep on the 30th and 31st. Seven days of falling weather.

Greatest deg. of heat on the 4th, at 2, P. M.---barom. 29, 92---wind S. W.---fair. Greatest deg. of cold on the 15th, at 10, P. M.---barom. 30, 73---wind N. N. W.---fair. Barom. highest on the 8th, at 10, P. M.---therm. 37°---wind W. N. W.---fair: lowest on the 31st, at 10, P. M.---therm. 37°---wind N. W.---snowed.

Diseases in *Ipswich*; pulmonary consumptions, hæmoptoes---Very healthy: In *Salem*; flow fevers, pleurifies, rheumatisms, bad coughs, putrid sore throats: In *Beverly*; cholics, tooth-ach, coughs, &c.

Thermometer.

360 *Meteorological Observations for the Year 1783.*

1782.	Thermometer.			Barometer.			Rain.
	Greatest Height.	Least Height.	Mean Height.	Greatest Height.	Least Height.	Mean Height.	
January,	45	6	26	30, 88	29, 90	30, 37	
February,	40	6	29	30, 99	29, 62	30, 34	
March,	50	21	37	30, 70	29, 43	30, 06	
April,	68	39	49	30, 53	29, 65	30, 01	
May,	68	47	56	30, 32	29, 28	29, 92	
June,	88	54	70	30, 43	29, 10	29, 72	
July,	84	60	69	30, 05	29, 06	29, 54	
August,	85	55	70	30, 30	29, 20	29, 77	
September,	86	47	62	30, 40	28, 97	29, 92	0,703
October,	64	42	51	30, 52	29, 59	30, 04	3,133
November,	55	22	40	30, 88	29, 50	30, 12	4,533
December,	53	17	35	30, 83	29, 37	30, 13	3,601
Whole Year,	88	6	50	30, 99	28, 97	29, 99	11,970 Since Aug.

1783.

JANUARY.

	Therm.			Barom.			Rain.
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	42	46	45	30, 90	30, 86	30, 82	
Lowest,	7	12	14	29, 48	29, 41	29, 42	
Mean stat.	28	32	32	30, 10	30, 05	30, 06	4,033

The state of the atmosphere variable, and our feelings very disagreeably affected by the constant vicissitudes of a mild and extreme cold air. The wind frequently between N. and N.E. and between S. W. and W. but prevailed mostly between W. and N. W. On the 8th, at 9, P. M. the therm. abroad, 5° below c, and, at 8 the next morning, 10° below o. The ground covered with snow from the 5th to the end of the month. A severe snow-storm on the 10th, with N. E. wind. Eleven days of falling weather. Snow fell twenty-three inches in the month.

Greatest deg. of heat on the 25th, at 1, P. M.---barom. 29, 68---wind W. S. W.----fair. Greatest deg. of cold on the 9th,

9th, at 8, A. M.---barom. highest---wind W. N. W.---fair.
Barom. lowest on the 19th, at 1, P. M.---therm. 44°---wind
S. W.---fair.

An Aurora Borealis in the night of the 26th---wind N. W.
preceding days fair---the four following, cold, with sprinklings
of snow.

Diseases in *Ipswich* ; pleuritic fevers, anginas, coughs, tooth-
achs : In *Salem* ; bad coughs, anginas, tooth-achs, rheuma-
tisms, pleuritic fevers : In *Beverly* ; remitting fevers, and
nervous.

FEBRUARY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P. M.	
Highest,	51	53	52	30, 84	30, 61	30, 83	Rain.
Lowest,	1	12	10	29, 76	29, 64	29, 73	Inch.
Mean stat.	34	37	37	30, 28	30, 19	30, 26	4,907.

The weather more capricious than the last month. The va-
rieties of cold, warm, fair, cloudy, rainy, snowy and foggy
weather were experienced every few days through the month.
on the 3d, at 8, A. M. the therm. out doors, stood at 8° be-
low 0. Farmers plowed on the 21st. Winds variable, but
most prevalent from S. W. to W. Ground covered with snow
until the 18th. A very dense smoke-like fog in the evening of
the 10th, attended with a singular kind of scent, somewhat
resembling that of burned leaves. Thirteen days of cloudy and
falling weather. Ten inches of snow fell during the month.

Greatest deg. of heat on the 19th, at 2, P. M.---barom.
lowest---wind S. S. W.---misty. Greatest deg. of cold on the
3d, at 7, A. M.---barom. 30,37---wind W. N. W.---fair.
Barom. highest on the 9th, at 7, A. M.---therm. 27°---wind
N. E.---cloudy.

A faint Aurora Borealis in the evening of the 2d---wind W. N. W.—and of the 27th---wind W.---fair for several days after them.

Diseases in *Ipswich*; coughs, bilious cholics, rheumatisms—Healthy: In *Salem*; mild, continued and rheumatic fevers, bad coughs: In *Beverly*; inflammations of the eyes, tumors.

MARCH.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Highest,	50	56	55	30, 73	30, 41	30, 53	Rain.
Lowest,	16	24	21	29, 30	29, 30	29, 28	Inch.
Mean stat.	33	43	40	30, 12	30, 02	30, 05	1,733

Several small snows, which soon melted; the air mild. Predominant winds from S. S. W. to N. W. The ground bare the greater part of the month, and very little froze. Six days of falling weather.

Greatest deg. of heat on the 29th, at 1, P. M.---barom. 29, 72---wind S. E.---misty. Greatest deg. of cold on the 11th, at 7, A. M.---barom. 30, 50---wind W. N. W.---fair. Barom. highest on the 13th, at 7, A. M.---therm. 25°---wind N. N. W.---fair: lowest on the 8th, at 11, P. M.---therm. 43°---wind very high at N. N. W.---fair.

A small Aurora Borealis in the evenings of the 2d and 26th---wind W. N. W.—the following days fair. In the evening of the 29th, the heavens were illuminated with a very bright and singular northern light. At 8^h. 4', when I first saw it, the northern heavens, as far as E. N. E. and W. S. W. were interspersed with numerous Auroral clouds, and very bright spots, somewhat resembling lighted torches. From the luminous spots converging corruscations shot up, with a quick and tremulous motion, towards the zenith. The luminous clouds

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were

were continually changing their form and situation, moving with a waving or flashing motion. At the same time, there was a bright glade or zone of light, composed of very fine striæ, S. of the zenith; which extended across the hemisphere, in the S. E. and S. W. points, within 25° of the horizon. The southern limb of the zone extended almost as far as the cloudy star in *Cancer*, which was nearly on the meridian. At $8^{\text{h}} 15'$, the striæ in the zone, and striated corruscations from every other direction, approached towards a common center in the neck of *Leo major*, and formed a kind of vortex, which soon became two segments of a circle, and then changed into detached, flashing clouds. At $50'$ after 8^{h} , a very extensive and dense Auroral cloud was formed in the W. and N. W. with numerous striæ curiously turned around its heads and indentations. At half after 9^{h} , corruscations from the N. extended beyond the zenith. At 10^{h} , the light appeared only in the N. and greatly diminished. There appeared to be an extremely rare fluid almost continually flashing beneath the striated vapour, in various directions. The wind at W. and very small till 10^{h} , when it breezed up fresh at N. W. At 10^{h} , therm. 53° , barom. 29, 72. Five preceding and seven following days fair.* Faint

X x 2

northern

* By a letter from the Reverend Dr. Stiles, President of Yale-College, which I received soon after, it appears, that the extent of this northern light near the zenith, and the meeting of the corruscations, were observed at *New-Haven*, (computed distance 180 miles, S. W.) to be as far S. and nearly in the same points in the heavens, as they were here. He says, that "At $8^{\text{h}} 10'$, the Auroral corruscations "from the eastern, western and northern heavens, concurred in a center 12° S. of "the zenith, in a line from the two stars (*Castor* and *Polux*) in the head of *Gemini* "to *Cor Leonis*. Had it been at the summit of the atmosphere, it must have appeared 45° or 50° S. of the zenith, at the distance of fifty miles N. of *New-Haven*; "and yet the Reverend Mr. Atwater, of *Westford*, fifty miles N. observed it at $8^{\text{h}} 10'$, very nearly in the same place, and not S. of *Cor Leonis*.

northern lights in several of the preceding and following nights. Two bright parhelia on the 8th, in the morning.

Diseases in *Ipswich* ; coughs, pulmonic complaints—Healthy : In *Salem* ; inflammatory, pleuritic and rheumatic fevers, abscesses : In *Beverly* ; pulmonic fevers, rheumatisms, worms, &c.

APRIL.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	60	80	71	30, 70	30, 52	30, 57	Rain.
Lowest,	38	40	40	29, 30	29, 32	29, 20	Inch.
Mean stat.	47	54	50	30, 10	30, 00	30, 07	1,007

The weather warm and pleasant. Winds principally from S. to W. N. W. The air frequently smoky. The 17th, excessive warm for this month ; the therm. ranged at 82° , within doors, at 5, P. M. The ground very dry, which seems to have retarded vegetation. Five days on which rain fell.

Greatest deg. of heat on the 17th, at 2, P. M.---barom. 29, 49---wind S. W.---fair. Greatest deg. of cold on the 13th, at 7, A. M.---barom. 30, 44---wind N. N. W.---fair. Barom. highest on the 24th, at 6, A. M.---therm. 48° ---wind N.---cloudy : lowest on the 12th, at 11, P. M.---therm. 42° ---wind N. W.---rainy.

Early in the evening of the 7th, there appeared a bright Aurora Borealis, forming an arc about 20° above the horizon in the N. At 20' after 8^h, the brightness greatly increased ; and lucid spots, resembling torches, at different heights above the arc, emitted numerous coruscations. At 8^h 46', a very bright Auroral zone was formed from E. to W. N. W. passing the meridian near the zenith. Its motion was visible and uniform towards the S. preserving its position as to the E. and W. points.

points. It appeared to be a luminous vapour of considerable density, somewhat broken near the meridian; but the edges were so well defined that its breadth was easily measured with a sextant. The mean of the breadth, taken at several times and in different parts, was $16^{\circ} 10'$. In its progress, it passed above several small clouds, which appeared very black, accurately defined, and far below the luminous vapour. After passing a little S. of *Procyon*, which it entirely obscured, it became stationary at $36^{\circ} 20'$ S. of the zenith. In a few minutes the light grew faint, and, at $9^h 2'$, wholly disappeared. Soon after, another similar zone formed N. of the zenith, but much fainter, and not so broad as the former. It passed $5^{\circ} 40'$ S. of the zenith, and disappeared. Before 9^h the light in the N. was greatly diminished, and appeared like a common Aurora. The wind was N. W. and very small. At 9^h , therm. 49° ---barom. 30,19. The preceding day, cloudy and rain---the third day after, rain and hail. There were also faint Auroras in the evenings of the 12th, 26th and 27th---the wind N. W.---rain on the day preceding that of the 12th, and rain, with thunder and lightning, that of the 26th---the succeeding days fair and cool.

Diseases in *Ipswich*; pleuritic fevers, worms, cholics, ophthalmias: In *Salem*; inflammatory and flow fevers, cholics, bad coughs: In *Beverly*; rheumatisms, coughs,

MAY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.	
Highest,	67	78	69	30,59	30,32	30,42	Rain.
Lowest,	45	50	49	29,42	29,33	29,42	Inch.
Mean stat.	51	61	57	30,02	29,88	29,96	4,005

Plentiful

Plentiful rain on the 8th, 9th and 10th, but the air very cool after it, especially in the night, which greatly retarded vegetation. Winds most prevalent from S. S. W. to W. N. W. Seed sowed last month lay long in the ground, and much of it perished. Eight days on which rain fell.

Greatest deg. of heat on the 18th, at 1, P. M.----barom. lowest---wind S.---fair. Greatest deg. of cold on the 5th, at 7, A. M.----barom. 29,79----wind N. W.----fair. Barom. highest on the 28th, at 6, A. M.---therm. 53°---wind N.W. ---fair.

Faint Aurora Borealis in the evenings of the 2d and 13th---wind N. W.---clouds and rain succeeded them. Severe thunder and lightning on the 23d, at 5, P. M.

Diseases in *Ipswich*; flow fevers, coughs, measles: In *Salem*; measles epidemic, inflammatory fevers, rheumatisms: In *Beverly*; anginas, tonsillaris, tumors.

JUNE.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	76	86	85	30,42	30,41	30,41	Rain.
Lowest,	53	57	54	29,45	29,10	29,38	Inch.
Mean stat,	66	75	69	29,78	29,58	29,73	3,438

The temperature of the atmosphere, this month, exceedingly warm and moist, which produced a most rapid vegetation. Winds most prevalent from S. to W. Apple-trees less injured by canker-worms than the last year. Twelve rainy days.

Greatest deg. of heat on the 19th, at 2, P. M.---barom. 29,17---wind S. W.---fair. Greatest deg. of cold on the 1st, at 6, A. M.---barom. highest---wind N.E.---cloudy. Barom. lowest on the 8th, at 2, P. M.---therm. 75°---wind very high at S. W.---fair.

Very

Very faint Aurora Borealis in the evenings of the 13th and 29th---wind W.---showers on the following days. Frequent thunder and lightning.

Diseases in *Ipswich*; flow fevers, measles, erysipelas, worms, pulmonary consumptions: In *Salem*; measles, disorders of the first passages, synochi, peripneumonies: In *Beverly*; measles epidemic.

JULY.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Highest,	81	89	85	30, 15	30, 07	30, 12	Rain.
Lowest,	60	64	62	29, 27	28, 96	29, 26	Inch.
Mean stat.	68	73	65	29, 74	29, 58	29, 70	9, 062

The weather very hot, with frequent heavy showers of rain. Vegetation very luxuriant. Grass, however, suffered so much by the drought and cold in the spring, that the crop of hay was indifferent. Grain of all kinds appeared very fine, but is greatly injured by mildew. Flax and garden esculents exceeding good. Indian corn in a most flourishing state. Garden and wild fruit, plenty. Predominant winds from S. W. to N. W. Twelve rainy days. Frequent thunder and lightning.

Greatest deg. of heat on the 25th, at 2, P. M.---barom. lowest---wind S. W.---shower approaching. Greatest deg. of cold on the 1st, at 6, A. M.---barom. 29, 78---wind N. E.---cloudy. Barom. highest on the 29th, at 6, A. M.---therm. 63°---wind N. W.---fair.

Diseases in *Ipswich*; measles, diarrhæas, flow fevers, pulmonary complaints: In *Salem*; dysenteries, diarrhæas, ophthalmias, inflammatory fevers: In *Beverly*; measles epidemic.

AUGUST.

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AUGUST.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.	
Highest,	78	88	85	30, 20	30, 22	30, 25	Rain.
Lowest,	55	61	59	29, 38	29, 08	29, 07	Inch.
Mean stat.	66	72	68	29, 80	29, 37	29, 75	4,438

The air, by turns, very warm and very cool, for this season. On the morning of the 10th, considerable frost in low ground. At the eastward, it is said to have been so severe as to destroy most of the fields of Indian corn. On the 24th, the therm. in the shade abroad, ranged at 95°, at 2, P.M. Repeated large showers of rain. Prevailing winds between S. W. and N. W. Eleven days on which it rained.

Greatest deg. of heat on the 24th, at 1, P.M.----barom. lowest---wind S. S. W.---fair. Greatest deg. of cold on the 10th, at 6, A.M.---barom. 30, 20----wind N. W.----fair. Barom. highest on the 26th, at 10, P.M.----therm. 61°----wind N. E.---cloudy.

Small Aurora Borealis in the evening of the 16th---wind W.---and of the 19th---wind N. W. Rain and thunder the second day after the first---fair several days after the last. Thunder and lightning on the 3d, 8th, 13th and 18th.

Diseases in *Ipswich*; pulmonic and asthmatic disorders, worms—Very healthy: In *Salem*; flow and rheumatic fevers, synochi, diarrhæas, dysenteries, cholera morbus, cholics, vomiting and purging among children: In *Beverly*; measles, diarrhæas, worms.

SEPTEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.	
Highest,	69	70	64	30, 38	30, 36	30, 40	Rain.
Lowest,	45	49	49	29, 60	29, 30	29, 47	Inch.
Mean stat.	57	62	57	29, 95	29, 80	29, 91	1,448

The

The weather variable. Predominant winds from S. W. to N. Frost on the 4th and 23d, but only very tender plants injured. Garden esculents in great plenty and perfection. Ten days on which rain fell.

Greatest deg. of heat on the 14th, at 1, P. M.---barom. lowest---wind S.W.---fair. Greatest deg. of cold on the 23d at 7, A. M.---barom. 30, 38---wind N. W.---fair. Barom. highest on the 26th, at 9, P.M.---therm. 52°---wind N.---fair.

Diseases in *Ipswich*; worm cases—Very healthy: In *Salem*; Synochi and flow fevers, abscesses, cynanche maligna, vomiting and purging among children: In *Beverly*; measles, anginas, abscesses.

OCTOBER.

	Therm.				Barom.			
	A. M.	Noon.	P. M.		A. M.	Noon.	P. M.	
Highest,	55	61	67		30, 61	30, 52	30, 60	Rain.
Lowest,	40	43	42		29, 39	29, 15	29, 38	Inch.
Mean stat.	49	53	51		30, 02	29, 91	29, 96	11, 607

High winds and heavy rains. A very severe storm of rain on the 9th, and on the 18th and 19th, attended with excessive high winds at N. E. Towards the close of the storm on the 19th, considerable quantity of snow fell, but soon melted. In the morning of the 11th, heavy thunder, with hail and rain: also, severe thunder and lightning, with hail and rain, in the evening of the 31st---several buildings struck, and creatures killed. Predominant winds from N. W. to N. E. Large crops of Indian corn. Apples, and other fall fruit, in greater plenty than the last year. No severe frosts. Grass, and many kinds of vegetables retained their verdure through the month. Rained on fourteen days.

Greatest deg. of heat on the 23d, at 1, P.M.---barom. lowest---wind S.S.W.---rainy. Greatest deg. of cold on the 26th, at 7, A. M.---barom. highest---wind W. S. W.---fair.

Y y

Diseases

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Diseases in *Ipswich* ; continued fevers, worm cases very rife :
In *Salem* ; slow and scarlet fevers, fynochi, pleurifies.—Sickly :
In *Beverly* ; bilious remitting fevers.

NOVEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	49	53	52	30, 80	30, 80	30, 84	Rain.
Lowest,	25	28	26	29, 16	29, 23	29, 37	Inch.
Mean stat.	36	40	39	30, 07	30, 07	30, 08	5,666

Very cold, blustering and stormy. Winds frequently very high, and most prevalent between W. and N. Ground froze hard on the 11th---snow fell on the 12th, and did not wholly go off during the month. Snowed, likewise, on the 28th and 29th---about four inches fell in the month. Nine days of falling weather.

Greatest deg. of heat on the 4th, at 1, P. M.---barom. 30, 03---wind W. S. W.---fair. Greatest deg. of cold on the 23d, at 8, A. M.---barom. 30, 56---wind W. N. W.---fair. Barom. highest on the 18th, at 11, P. M.---therm. 32°---wind W.---fair : lowest on the 28th, at 8, A. M.---therm. 38°---wind N. E.---snowed.

A small shock of an earthquake about 11 o'clock in the night of the 29th, but was felt by very few people in this town.

Diseases in *Ipswich* ; continued fevers, worm cases, coughs :
In *Salem* ; low, depressed fevers, cynanche maligna : In *Beverly* ; bilious remitting fevers.

DECEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Highest,	55	54	54	30, 72	30, 58	30, 63	Rain.
Lowest,	14	16	17	29, 18	29, 09	29, 30	Inch.
Mean stat.	34	37	36	30, 10	30, 03	30, 07	4,933

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The former part of the month rather mild and pleasant, but the latter, blustering, stormy and cold. The ground mostly bare to the 18th, and then covered with snow to the end of the month. Predominant winds from W.N.W. to N.E. Seventeen days of falling weather. Snow fell fourteen inches deep during the month.

Greatest deg. of heat on the 12th, at 8, A. M.----barom. 29,84---wind S.W.---fair. Greatest deg. of cold on the 24th, at 8, A.M.---barom. 30,35---wind W.N.W.---fair. Barom. highest on the 15th, at 8, A.M.---therm. 30°---wind N.N.W.---fair : lowest on the 1st, at 1, P. M.---therm. 41°---wind N. E.---rainy.

Diseases in *Ipswich* ; putrid fevers, coughs, worm cafes—Healthy : In *Salem* ; febrile disorders frequent, as pleurifies, rheumatisms, catarrhal fevers, cynanche maligna, abscesses : In *Beverly* ; hæmoptoes, flow fevers, coughs.

1783.	Thermometer.			Barometer.			Rain.
	Greatest Height.	Least Height.	Mean Height.	Greatest Height.	Least Height.	Mean Height.	
January,	46	7	31	30, 90	29, 41	30, 07	4,033
February,	53	1	36	30, 84	29, 64	30, 24	4,907
March,	56	16	39	30, 73	29, 28	30, 06	1,733
April,	80	38	50	30, 70	29, 20	30, 06	1,007
May,	78	45	56	30, 59	29, 33	29, 95	4,005
June,	86	53	70	30, 42	29, 10	29, 79	3,438
July,	89	60	69	30, 15	28, 96	29, 67	9,062
August,	88	55	69	30, 25	29, 07	29, 64	4,438
September,	70	45	59	30, 40	29, 30	29, 89	1,448
October,	67	40	51	30, 61	29, 15	29, 96	11,607
November,	53	25	38	30, 84	29, 16	30, 07	5,666
December,	55	14	36	30, 72	29, 09	30, 07	4,933
Whole Year,	89	1	50	30, 90	28, 96	29, 95	56,277



XVI. *An Account of several Strata of Earth and Shells on the Banks of York-River, in Virginia; of a subterraneous Passage, and the sudden Descent of a very large Current of Water from a Mountain, near Carlisle; of a remarkably large Spring near Reading, in Pennsylvania; and also of several remarkable Springs in the States of Pennsylvania and Virginia. In a Letter from the Hon. BENJAMIN LINCOLN, Esq; F. A. A. to the Rev. JOSEPH WILLARD, V. Pres. A. A. and President of the University at Cambridge.*

THAT this earth, since its formation, has met with great changes, and that the shores, now covered with the tallest cedars and most luxuriant plants, were once washed by the ocean, none can deny. The land between *James-river* and *York-river*, in *Virginia*, is very level; its surface being about forty feet above high-water mark. It appears to have arrived to its present height at different periods, far distant each from the other, by means of the ocean: for, near *York-town*, where the banks are perpendicular, you first see a stratum of earth, about five feet high, intermixed with small shells, which has the appearance of a mixture of clay and sand. On that lies, horizontally, a stratum of white shells, the cockle, the clam, and others, an inch or two thick; then a body of earth, similar to that first mentioned, eighteen inches thick: and on that lies another thin body of small shells, then a third body of earth, about the same thickness as the last; and on that lies another body of white shells, of various kinds, about three feet thick, with very little sand, or earth, mixed with them. On these lies a body of oyster-shells, about six feet thick; then a body of earth to the surface. The oyster-shells are so united by a very strong

strong cement, that they fall only when undermined, and then in large bodies, from one to twenty tons weight. They have the appearance of large rocks on the shores, and are wasted by the frequent washing of the sea. All these different strata seem to be perfectly horizontal.

After riding about seven miles from *York-town*, near the center between the two rivers, I discovered, at a place from which a large body of earth had been removed to a mill-dam, nearly the same appearance as in the bank first mentioned.

What they call their stone, with which they build in *York-town*, is nothing more than shells, united by a strong cement, which seems to be petrified in a degree, but is apparently affected by the weather.

ON the 2d of August, being at *Carlisle*, in the state of *Pennsylvania*, I went to view a subterraneous passage, which had its entrance near a river into a rock. I followed it about two hundred and fifty feet : to this distance it was, in general, from six to seven feet high, and about the same in width. At the end of two hundred and fifty feet it divided into three branches.—As they were smaller, and more difficult to follow, and finding myself exceedingly chilled, (which cost me one of the sickest nights I ever suffered) I gave up the pursuit, though I had proceeded but about half the distance, as I was informed by Col. *Butler*, who had been near the end. It appeared to me that it was a water-course, as the rocks were worn smooth, and indented in the manner they usually are by a long running of water over them. The appearance over head was curious ; some parts were smooth like the sides ; other parts represented various figures, formed by the water which had penetrated through the pores.

pores of the rock, and was now petrified and petrifying on its surface. The bottom was apparently earth and small stones.

About three years since, the people in the vicinity of this town, who lived near the mountain which is about ten miles from the village, were alarmed by a current of water overflowing the banks of the river. The cause they could not investigate, as there had been, the night before, but a small rain: however, they soon found the first effects of the water appeared within about twenty feet of the top of the mountain. Whether it burst forth from the mountain, or was a column of water from the clouds, has not yet been ascertained. The course in which it ran down the mountain was dry the next morning. It was confined to the width of twenty feet, perhaps less. It appeared to be about thirty feet deep, as could be discovered by its effects on those trees which were not carried away by the water. It cut a passage in the side of the mountain, of about seven or eight feet wide, and near that depth. The traces of it are seen from the town, though, as I said before, it is ten miles distant. One rock, of a very considerable weight, was thrown into the crotch of a tree, twelve feet from the ground, in which it remained for some time. When the water came into the valley, its impetuosity was so great that it was not immediately diverted, but reached a small rising ground, through which it cut a passage; then followed the valley, and so on to the river, which was at some considerable distance. In its course, it carried off all the fences, and came upon the floors of some of the houses. I have had some conversation with Mr. *Rittenhouse* on the subject, who has been twice to see the effects of the water. It is his opinion, that it was not a column of water which burst forth from the mountain, as it was near the top of one of the highest. On

On my return to *Philadelphia*, in the neighbourhood of *Reading*, I came to the greatest spring of water I had ever seen.—It is about fourteen feet deep, and about one hundred feet square. A full mill-stream issues from it. The water is clear and full of fishes. To account for this body of water, was my enquiry. I soon found, that it was probably the rising and bursting forth of a very considerable river, which sunk into the ground and totally disappeared, one mile and an half or two miles distant from this place.

In the northern parts of *Pennsylvania*, there is a creek, called *Oil-Creek*, which empties itself into the *Alleghana-river*, issuing from a spring, on the top of which floates an oil, similar to what is called *Barbadoes* tar, and from which may be collected, by one man, several gallons in a day. The troops, in marching that way, halted at the spring, collected the oil, and bathed their joints with it. This gave them great relief, and freed them immediately from the rheumatic complaints with which many of them were affected. The troops drank freely of the waters :—they operated as a gentle purge.

There is another spring in the western parts of *Virginia*, as extraordinary in its kind as the one just mentioned, called the *Burning-Spring*. It was known a long time to the hunters. They frequently encamped by it for the sake of obtaining good water. Some of them arrived late one night, and, after making a fire, they took a brand to light them to the spring. On their coming to it, some fire dropped from the brand, and, in an instant the water was in a flame, and so continued, over which they could roast their meat as soon as by the greatest fire. It was left in this situation, and continued burning for three months without intermission. The fire was extinguished by
excluding

excluding the air from it, or smothering it. The water taken from it into a vessel will not burn. This shews, that the fire is occasioned by nothing more than a vapour that ascends from the waters.

There are two springs high up on the *Powtomack*; one of which has about the same degree of heat as blood running from the veins. It is much frequented by people who have lost their health. The waters are drank with freedom, and also serve as a hot bath, by which much good has been experienced. The other spring, issuing from the same mountain, a little further up, is as remarkable for its coldness, as the other for its heat, and differs from common springs in as many degrees.

These accounts I have from the best authority. General *Washington*, from whom I had my information, as well as from others, owns the land around the *Burning-Spring*, which he bought for the sake of it.

The accounts of the other springs I received from a gentleman of undoubted veracity, and of great observation, who lately visited them. He commanded the troops who experienced the benefit of the *Oil-Spring*. He mentioned to me another spring in the south-westerly part of *Virginia*, which he had not seen, but of which he had received a particular account from gentlemen of character. It is called the *Sweet-Spring*, from the sweetness of the waters, which have been found efficacious in many disorders, and have given relief when every other attempt has proved ineffectual.

To these I may add the great number of salt springs in *America*, especially on the *Ohio*, and the rivers which empty into it. There is one spring on the *Mississippi*, from which salt is made sufficient to supply the whole *Illinois* country with that article.



XVII. *An Account of large Quantities of a fossil Substance, containing Vitriol and Sulphur, found at Lebanon, in the State of New-Hampshire, accompanying a Specimen. In a Letter from the Reverend JEREMY BELKNAP, F. A. A. and Member of the Philosophical Society at Philadelphia, to SAMUEL WILLIAMS, L. L. D. F. A. A. and Hollis Professor of Mathematics and Philosophy in the University at Cambridge.*

Dover, September 28, 1780.

SIR,

HEREWITH I send you a specimen of a stone, which, by the efflorescence upon it, you will see to be rich in vitriol, and by the smell, you will perceive to contain a great proportion of sulphur. It was taken out of the cellar-wall of an house at *Lebanon*, in the county of *York*, where it had been placed for about fifteen years. The same kind of stone is found in vast quantities, for a considerable distance round the spot. The neighbouring people use it for dyes, and for blacking leather, with as much success as the best imported copperas. As there is plenty of wood and water there, I think a manufactory might be established to great advantage. You will judge whether this hint is worth communicating to your newly established Society.

I am, Sir,

Your friend and humble servant,

JEREMY BELKNAP.

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XVIII. *An Account of yellow and red Pigment, found at Norton, with the Process for preparing the Yellow for Use; accompanied with Specimens. In a Letter from the Reverend SAMUEL DEANE, F. A. A. to Mr. CALEB GANNETT, Rec. Sec. A. A.*

Falmouth, May 30, 1782.

S I R,

IN several places in *Norton*, in the county of *Bristol*, in the *Massachusetts*, has been found a fossil, near the surface of the earth, mixed with sand and small pieces of iron ore, from which is extracted two kinds of substances useful in painting, viz. yellow and red.

To make the yellow, the process is as follows: They mount a tub, or vat, on blocks two feet high, and put into it one third part as much of the earth as will fill it: then fill it up, almost to the brim, with water. After this, with hoes, they bruise it; and stir it about till it is dissolved and well mixed with the water. The sand, gravel and iron ore, in about the space of a minute, will sink to the bottom; at which time they draw off the water, with the pigment floating in it, letting it fall through a common bread-sieve, into a vat, or tub, standing on the ground. When the paint is all sunk to the bottom, the water is taken off through holes in the sides, and the paint dried well in the open air and sunshine, on a floor made tight and surrounded with a border, to prevent its running off. Being thoroughly dried, it is fit for grinding by the painter, making a greenish yellow colour. And I am told, a little black paint mixed with it, renders it a beautiful olive colour.

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Mr. DEANE's Account of Pigment found in Norton. 379

The yellow paint, being dried as above, and then brought to a red heat, in a kettle over a hot fire, becomes a red paint resembling *Spanish*-brown, but of a finer and brighter colour. It is used by painters instead of *Spanish*-brown. They use it for out-door work ; and time will soon discover whether it will not be equally durable. The manufacturers sell it for about three pence a pound, which is cheap ; and it bids fair to be of great service to the public.

In the same town is found a white fossil, out of which is made a paint resembling *Spanish*-white, or whiting. But concerning this I have not been able to gain much information.

I have left samples of the yellow and red with the Keeper of the Cabinet : and if you think fit, you may communicate this to the Academy at their next meeting.

I am, Sir,

Your most humble servant,

SAMUEL DEANE.

Mr. Gannett.

P. S. Since writing the above I find, that this paint has stood the weather well, in several instances, for three or four years ; and bids fair to prove durable : and that the *red*, in its present state, is sold at fifteen shillings per hundred weight ; which is cheaper than can be obtained from *Europe*.

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XIX. *An Account of an Oil-Stone found at Salisbury. In a Letter from the Reverend SAMUEL WEBSTER, to Mr. CALEB GANNETT, Rec. Sec. A. A.*

Salisbury, January 24, 1783.

S I R,

I HAVE found what the goldsmiths use, and call an oil-stone, equal, if not superior, to those imported from *Turkey*.—But as it was so small as only to make two, one for each of my sons, who are goldsmiths, it is not in my power to send you a sample. It is extremely hard, and somewhat brittle; so that I easily broke it into two pieces. When it is ground it is exceedingly smooth, and serves to smooth their engraving tools. I found it in my field by accident, and was excited, from its uncommon appearance, to take it up, not knowing, at that time, what it was. It is somewhat curdled with light and dark brown, or, when ground, it approaches to a light chocolate colour, somewhat clouded. Before it was ground some compared it to *Castile* soap. I have made considerable search for more, but without success. I doubt not, however, that we have them in the country, perhaps in plenty. I found this in moist ground. These stones are necessary for all those who make use of engraving tools, and are now very scarce and dear.

I send you a piece of marble found near the mouth of *St. John's-River*, in *Nova-Scotia*. It is found of various colours,—white, bluish and veined. I also send you a sample of salt, made from a salt-spring in the *Seneca* country, on *Mohawk-River*: and a sample of cloth, coloured black with sumach-berries alone, without copperas.

I am, &c.

SAMUEL WEBSTER.

Mr. Caleb Gannett.



XX. *Observations on the Culture of Smyrna Wheat. In a Letter from BENJAMIN GALE, F. A. A. Member of the Philosophical Society at Philadelphia, and Fellow of the Royal Society in London, to his Excellency JAMES BOWDOIN, L. L. D. Pres. A. A.*

Killingworth, 25th August, 1783.

S I R,

I SEND you a few heads of the true *Smyrna* wheat, a species of that grain, which I apprehend is the best adapted for the horse-keeping husbandry, believing it will answer for tillage equal to our Indian corn. Dr. Elliot made various attempts to procure it, without succeeding. This happens to be much blasted, owing partly to the season, and in part to being late sowed, viz. late in September, after the rains came on, at the end of a long drought; and being sowed in my garden, contiguous to some barberry-bushes; to all which, by leaving open my gate, my sheep got in during the winter, the ground not being covered with snow, ate it off even with the ground.—But am of the opinion, from the strength of the stalk, a specimen of which I also send you, a part of the second joint, divested of the leaf which covers it, and also the upper joint which supports the ear, which is solid, it appears better able to support the heads, and will not be subject to a rupture of the vessels, which is often the case in a blasting season; and from its being about ten days earlier than common wheat, puts it still further more out of the danger of the blast. Those ears which have but one head, I apprehend, from the similarity of the leaf and stalk, are of the same species with those which have more heads: one of which has four ears of a side, springing out of the main ear,

ear, which I apprehend owing to having more room, more culture, and, perhaps, the earth, contiguous to the roots, richer. The method of culture, if you are not acquainted with *Tull's* tillage, is, to make a small ridge, in form of a bed for peas, on which make two rows, at about ten inches distant, and the seeds planted at about half an inch distance in the rows, which must be hoed, and kept clean from grass or weeds. Should you not have a curiosity yourself, in this way, you may perhaps oblige some of your friends, who may be in the farming way. It would be well to put the seed into the ground soon.

I have the honour to be, Sir, &c.

BENJAMIN GALE.

Honourable James Bowdoin, Esquire.



XXI. *An Account of an Experiment for raising Indian Corn in poor Land. In a Letter from JOSEPH GREENLEAF, Esq; to the Reverend JOHN CLARK, F. A. A.*

Boston, May 26, 1785.

SIR,

WHILE I resided in the country, I found it was the opinion of the farmers, that whoever raised Indian corn paid more for it, in labour, than it was worth: that the land must be strong, highly manured, well plowed and hoed, or it would not produce a crop half equal in value to the expence bestowed upon it: that the land, in a very few years, would be worn out, and must lie useless a number of years afterwards to recover its fertility.

To convince them of their error, I purchased, of one of my neighbours, a piece of land which he affirmed was worn out, and unfit to produce any crop of any kind. The land was dry, and not a stone in it; the soil was very light and shallow, inclining to sand. The ground was over-run with briars and weeds, called *St. John's-wort*, with here and there a spire of coarse wild grass.

Upon this piece of ground I made the following experiments. In the first place I procured a plough, made under my own direction, with a sharp coulter, and a share about a fourth part of the size and weight of common plough-shares; and with a furrow-board, on a new construction, that followed the coulter edge-wise, turning the furrow over in rather a spiral form. With this plough, which required only the strength of a single horse, a furrow was ploughed through the whole length of my field, and

and, returning with the plough on the side next to which the furrow was turned, threw up another furrow against the first. At four feet distance from this another double furrow was ploughed, in the same manner; and so on, leaving a space of four feet between the double furrows, through the whole field. Upon these double furrows potatoes were planted, leaving the space of four feet between each hill. This field contained two acres and an half, and was about forty rods in length. It was ploughed and planted, in one day, with one horse and two boys. When the potatoes came up and wanted tending, the same boys, with the same horse and plough, turned another furrow of the unploughed ground towards the potatoes, on each side, and dressed them with their hoes: this they also performed in one day. At half-hilling, it was repeated, and the whole field became ploughed. At hilling, the field was cross-ploughed, the earth thrown towards the crop each way, and dressed with the hoe. By this mode, two acres and an half was compleatly tilled in four days, with the labour of only two boys and one horse; which, in the common way of managing ground, would have required ten days labour of one man, one boy, and two horses.

The next spring I ploughed, between every two rows of the old potatoe-hills, two furrows, which were thrown one against the other, and planted my corn upon them, without any manure. The ploughing and planting was performed by the same horse, plough and boys, in one day. My corn was husbanded in the same manner my potatoes were the year before. A field on the other side of the fence, much of the description and size of mine, was two days and an half in ploughing and planting, with one man, a boy, two horses, and a common plough. This field,
was

was planted on the same day with mine, and was well dunged. My corn made its appearance about two days before my neighbour's, ripened more than a fortnight earlier, and I had the largest crop.

I continued to plant corn in the same land, between the old hills as before-mentioned, for three years successively, without carrying on any manure,—the crops increasing about two bushels every year. My removing to *Boston* prevented my repeating the experiment. You will join with me in lamenting the loss to the public of thousands of acres of land that lie useless in this commonwealth, from a mistaken notion that such land is worn out, and not capable of producing a crop sufficient to pay even for the seed that is planted.

I am, &c.

JOSEPH GREENLEAF.

The Reverend John Clarke.

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XXII. *An Account of a singular Apple-Tree, producing Fruit of opposite Qualities ; a Part of the same Apple being frequently sour, and the other sweet. In a Letter from the Reverend PETER WHITNEY, to the Reverend JOSEPH WILLARD, V. Pres. A. A. and President of the University in Cambridge.*

Northborough, July 15, 1782.

REVEREND SIR,

THERE is now growing in an orchard, lately belonging to my honoured father, the Reverend *Aaron Whitney*, of *Petersham*, deceased, an apple-tree, very singular with respect to its fruit. The apples are fair, and, when fully ripe, of a yellow colour, but, evidently, of different tastes—sour and sweet. The part which is sour is not very tart, nor the other very sweet. Two apples growing side by side, on the same limb, will be often of these different tastes, the one all sour, and the other all sweet. And, which is more remarkable, the same apple will frequently be sour on one side, end, or part, and the other sweet, and that not in any order or uniformity ; nor is there any difference in the appearance of the one part from the other. And as to the quantity, some have more of the acid and less of the sweet, and so *vice versa*. Neither are the apples so different in their tastes, peculiar to any particular branches, but are found, promiscuously, on every branch of the tree. The tree stands almost in the midst of a large orchard, in a rich and strong soil, and was transplanted there about forty years ago. There is no appearance of the trunk or any of the branches having been ingrafted or inoculated. It was a number of years, after it had born fruit, before these different

ferent tastes were noticed ; but since they were first discovered, which is about twenty years, there has been constantly the same variety in the apples.

For the truth of what I have asserted, I can appeal to many persons of distinction, and of nice tastes, who have travelled a great distance to view the tree, and taste the fruit ; but to investigate the cause of an effect so much out of the common course of nature, must, I think, be attended with difficulty. The only solution I can conceive is, that the *corcula*, or hearts of two seeds, the one from a sour, the other from a sweet apple, might so incorporate, in the ground, as to produce but one plant : or that farina, from blossoms of those opposite qualities, might pass into, and impregnate the same seed. If you should think the account I have given you, of this singular apple-tree, will be acceptable to the *American Academy*, please to communicate it.

I am, &c.

PETER WHITNEY.

Reverend President Willard.

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XXIII. *A Letter from the Honourable BENJAMIN LINCOLN, Esq; F. A. A. to the Honourable JAMES WARREN, Esq; F. A. A. relating to the ingrafting of Fruit-Trees, and the Growth of Vegetables; inclosing the Observations of his Friend on the Growth of Trees downward after the first Year.*

Hingham, November 3, 1780.

MY DEAR SIR,

I TAKE this early opportunity, agreeable to my promise, to enclose you the sentiments of my friend on grafting, the growth of plants, trees, &c. These were given on a conversation which arose on my mentioning, that I had observed, for a number of years, an apple-tree in my orchard, the natural fruit of which was early, having been grafted with a winter cyon, producing fruit very like in appearance to the fruit produced by the tree whence the cyon was taken, but destitute of those qualities inherent in that fruit, and necessary to its keeping through the winter. This led me to call in question the propriety of grafting winter fruit on a summer stock, and to enquire, whether the stock through which, I supposed, the food passed to the cyon, and by which it was fitted properly to nourish the helpless and newly adopted branch, would not rather assimilate *that*, than that the cyon could, thus fed, retain all the qualities of its parent stock.

I am sensible that there are objections to this new system; and, perhaps, difficulties may be raised to it, which cannot be obviated.—But, as this may arise either from the erroneousness of the doctrine itself, or from the want of knowledge in the principles of vegetation, I think it should not be adopted or rejected

rejected without the fullest enquiry ; and especially, since a knowledge of the laws of vegetation is one of the most interesting matters which can be the subject of discussion : for on vegetation depends our being ; and in the same proportion as we obtain a knowledge thereof, and practise on that knowledge, in that proportion is our well-being promoted. That cultivation promotes vegetation, I think, none will deny : for surely the earth, spontaneously, gives us but a bare subsistence. The reasons assigned, why the earth did not more early bear fruit, were, because *there was no rain on the earth*, and because *there was no man to till the ground*.—The necessity of which seems to have produced one of the first decrees from heaven to man, even while he was in *Eden*, surrounded with all the blessings thereof, that he should dress the garden. Whether tilling and dressing the earth so prepares its parts that they became proper food for the plant, and thereby promote vegetation ;—whether, by tilling and dressing, the land is fitted properly to receive the rays of the sun, and to receive and retain a suitable quantity of water, with which food for the plant is supposed, by some, to fall ;—or whether, by tilling and dressing, the land does really partake of more particles necessary to vegetation, and so attracts like particles floating in the air, as similar bodies attract each other, and so light on, and feed the plant in their fall, or do rest on the earth, are absorbed by the roots, and thence conveyed thro' the whole plant, are questions which can, I think, be determined with more ease and greater certainty when the principles of vegetation are fully ascertained.

Please to favour me with the result of your enquiries on these matters, and it will much oblige him who has the honour to be, &c.

B. LINCOLN.

Hon. Gen. Warren.

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THE idea has universally obtained, that *Trees grow from the root upwards*. But perhaps it may appear probable, from the following considerations, that *Trees, from the first year, grow from the top downwards*.

The growth of annual plants seems to be the mere expanding of the parts contained in the seed, or bulb, which is a more perfect and full grown seed, differing but little from what is commonly called seed. Of this, the bulb of a tulip is the best example, as the parts are visible without the help of glasses. Upon removing the several coats of the bulb, each of which are the support of a leaf, in the center of it, a large flower, near half an inch in length, will be found, and, in thickness, as large as a rye-straw; in which the petals, stile, filaments and buttons are fully formed, and perfect in every respect but size and colour. The lower leaf of the plant, which, within the bulb, covers all the rest, swells and expands first: then the next above swells and expands; and so on, until the whole are expanded: after which, the stalk rises, the flower swells and opens, and its beautiful colours are separated and exhibited to the eye. In this growth the bulb is entirely wasted, except only the fine skin that covered each squamina, which remains much thinner than white paper. In the center of the bulb, below the leaves and adhering to the stalk, may be seen a very small bulb, much less than the seeds of the plant. This bulb is, however, increased with the growth of the leaves, until it becomes of the size of the parent bulb: and when the stalk, the leaves and fibrous roots decay and dry up, this new bulb remains, in the place of the old one, capable of a like growth the next year.

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The first year's growth of a tree, like that of plants, is the mere expansion of the parts contained within the seed, so far as those parts are fitted for growth ; and being expanded, the wood formed has no further growth, in any direction, but remains of the same size until it decays. Each leaf which grows on the first year's shoot, as well as those of succeeding years, has annexed to it, immediately above its stem, an embryo bud, which is nourished and fitted to grow the following year, and to become a branch of the future tree. The leaf having performed its maternal duty, falls to the ground, and manures the tree from whence it fell.

The wood of these saplings of a year, is uniformly of one texture ; but the wood of the next year is separated from it by a circular line, which remains as long as the wood lasts. Every succeeding year is distinguished in the same manner ; so that by cutting the tree on one side, from the circumference to the center, and counting those circles, you may ascertain its age.— And one of the main questions, arising in the consideration of this subject, is, how are these annual additional circles of wood formed ? Are they formed by the filling and expanding of fibres, which, too small for the observation of our senses, lie between the bark and the tree ? or are they new fibres shooting either from below or from above ? It appears, by examining the wounds of trees, that the wood being once separated never heals up and grows together.—The new wood grows over, and covers the wound ; but the separated vessels never unite again : therefore, if the edge of a knife be passed transversely thro' the bark half round a sapling, and those supposed extreme fine vessels were cut off, that side of the tree ought to cease growing, and the buds above it perish. But the fact is otherwise : for, cover

the wound so as the air may be prevented from carrying off the moisture, which, when uncovered, flows from the wound, the buds above will grow nearly as well as if the wound was not made. To suppose that new vessels, formed at the root, ascend, and seeking the buds, by passing round the incision, immediately find them, is too ludicrous an objection to be seriously noticed. Let us, then, consider the buds which are formed in the bosom of every leaf.

One of those buds, rended from its parent plant, and inserted in the bark of another tree of the same genus, will grow as well as if it had been continued where nature placed it, and become a compleat tree. Here, at least, there is a certainty, that there are no fibres calculated to support it, yet it will grow; and the whole tree, above the insertion in the stock, thus springing from a foster-bud, is exactly of the same nature in all respects, and produces the same fruit as the tree from which the bud was taken. This is the wonderful circumstance, which, though often attempted, has never been clearly accounted for. We shall proceed to enquire, then, how buds inserted in foreign stocks attain their growth.

When a bud is bro't into contact with the stock, and the bark of the stock passed round and upon the bark laid in with the bud, the sap very quickly forms a gum, which glues them together, and stops the mouths of those vessels which had been torn by separating the bark and bud from the parent tree. Whoever examines the fact, must be convinced, that the bud, thus laid in, never has any further adherence to the stock; but remains, during the life of it, liable to be separated from it by dissolving that gum; and, from this circumstance, the size and shape of the wood, or bark, laid in with the bud, may be plainly discovered

vered many years after its infertion. Here the communication between the stock and the bud is destroyed: for, if the sap penetrated this gum, it would dissolve it, and the bud would fall off; and there can certainly no fibres be sent from the root to feed a bud, which nature had not placed there. Nothing but experiment could induce a belief, that a bud, thus situated, would grow, become a tree, blossom and bear fruit. Let us see how buds grow in the situation assigned them by nature.

The largeness of the bud, and the freedom with which it shoots, renders the peach-tree a proper subject of this enquiry. Early in the spring, when the bud first begins to swell, we shall find one or more fibres shooting from it downward. These fibres are so large, below the bud, as apparently to swell the bark, and on removing the bark the fibres may be plainly seen by the naked eye. Whoever carefully examines this fact, will scarcely doubt that this is really the manner in which buds begin to grow. Inoculations having the same power of sending out fibres from themselves as buds, in their natural situations, need no nourishment from the stock on which they are fixed; but it becomes the question, from whence is their nourishment derived?

A curious yellow carnation, presented to a gentleman at Lancaster, in the year 1778, being transplanted very early in the spring, and the weather proving very cold, he was obliged to take it into the house, and keep it in a room where fire was kept. Notwithstanding his utmost care in keeping the earth well watered, the plant declined, the leaves became soft, and rested on the earth, and the plant shewed every symptom of approaching death. In this state, having bended twigs over the pot, he wet a thick tow-cloth and threw over the plant, which

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formed

formed a moist atmosphere round it. In a few hours the leaves became erect, and elastic, and within three days the whole plant assumed the aspect of perfect health. The roots had a full supply of moisture, but it did not grow; the leaves were supplied, and the plant instantly flourished.

The first appearance of vegetation among trees here, is the flowing of the sap in the sugar maple. This begins with the frosty mornings in the month of February. These hoar frosts never appear but when the air is moist; and it is invariably certain that the sap ceases to flow when the wind is at north-west and the air dry, be the state of the earth as to moisture or frost as it may. From hence it appears, that the sap is extracted from the air even before the leaf is expanded, and not from the earth, as is generally supposed.

The next appearance of vegetation, is the swelling of the bud in the scarlet maple; and in this, as in all other trees, it is to my purpose to observe, that the uppermost buds always swell first, and its beautiful blossoms are seen earliest to unfold on the topmost boughs. This cannot depend on a sap derived from the root; for, in that case, the lowermost should have unfolded first.

The husbandmen of *New-Jersey*, upon those lands which do not produce oak-timber sufficient for fencing, shave the bark from the pine trees in the latter part of winter, and in the spring, the turpentine running down over that part of the tree which has been barked, fills the pores, and preserving it against the water, renders the pine a very durable post for fencing. The turpentine, as I conceive, being collected from the air, descends from the top of the tree. This practice, lately introduced, deserves attention, not only as an argument in this question, but

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as an important lesson of instruction to those who live on pine lands.

The experiments made on fruit-trees, by extending their branches into green-houses while the roots remain in the ground, need not be repeated. They are better known than understood; and can only be accounted for by supposing that their nourishment is derived from the air. Of this the following experiment may be a proof.

A branch of the maple being separated from the tree, and the lower end sealed, placed in any part of the tree, will bloom as soon as any of the adjoining branches not separated from the tree will do. The buds of trees, deriving their nourishment from the air, send down their fibres between the bark of the tree and the former year's growth of wood, and lay an additional wood over the former growth. It is upon this principle alone, that the growth of inoculations can be accounted for; and it is clear and plain, that every bud has its own pith, perfectly distinct from the tree it is attached to, and has also in itself every other part of a tree.

From a due consideration of what has been said, it will appear, that the growth of annual plants is the expanding of the parts contained within their seeds as bulbs, and a production of other seeds and bulbs, perfectly distinct and unconnected with the former; but that the growth of trees after the first year is the expanding of buds, adhering to the former growth, and the fitting of other buds for future growth attached to the tree, as well as forming of seeds, as annual plants do.

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XXIV. *An Account of some of the vegetable Productions, naturally growing in this Part of America, botanically arranged.*
 By the Rev. MANASSEH CUTLER, F. A. A. and M. S.
 and Member of the Philosophical Society at Philadelphia.

IN an infant country, where nature has been liberal in her productions, and internal resources are greatly wanted, few objects can be of greater importance than natural history. Yet, unhappily, there is no branch of useful knowledge we have so little cultivated. The cultivation of this branch of science will open to our view the treasures we possess unenjoyed; and must eventually tend to the security and welfare of our citizens, the extension of their commerce, and the improvement of those arts which adorn and embellish life.

The little progress we have made in exploring the fossil kingdom, is sufficient to convince us, that the bowels of the country are well stored with minerals and other useful fossils; which are capable of being improved, not only for the benefit of individuals, but as national advantages.

We have, perhaps, as great a variety of indigenous plants, as any country produces, in a similar climate. But a great part of them have never been so far noticed as to receive even a trivial name. *Canada* and the southern states, beside the attention paid to their productions by some of their own inhabitants, have been visited by eminent botanists from *Europe*. But a great part of that extensive tract of country, which lies between them, including several degrees of latitude, and exceedingly diversified in its surface and soil, seems still to remain unexplored.

The almost total neglect of botanical enquiries, in this part of the country, may be imputed, in part, to this, *that Botany*
has

has never been taught in any of our Colleges, and to the difficulties that are supposed to attend it; but principally to the mistaken opinion of its inutility in common life. This opinion being so generally prevalent, it may be necessary to observe, that, tho' all the medical properties and œconomical uses of plants are not discoverable from these characters by which they are systematically arranged; yet the celebrated *Linnaeus* has found, that the virtues of plants may be, in a considerable degree, and most safely, determined by their *natural* characters: for plants of the same *natural* class are in some measure similar; those of the same *natural* order have a still nearer affinity; and those of the same genus have very seldom been found to differ in their medical virtues. Thus, according to the sexual system, plants of the second order in the third class are all esculent, affording food for men, beasts or birds; and no one species of all those numerous genera have been found to be poisonous. The starry plants of the first order in the fourth class are chiefly diuretic. The rough-leaved plants of the fifth class and first order are mucilaginous; but those of a disagreeable taste and smell, mostly berry-bearing plants, are more or less corrosive and poisonous. The umbelliferous plants, growing in dry places, are aromatic and stimulative, but in wet ground, often poisonous. Plants of the sixth class have roots, according to their smell or taste, either esculent or poisonous. The plants with horned antheræ of the eighth and tenth classes are astringent, and their berries acid and esculent. All the pulpy fruit of the twelfth class may be eaten with safety. Plants of the thirteenth class are chiefly poisonous: but those of the first order in the fourteenth are odoriferous, cephalic and resolvent; and none of them are poisonous. Nor is there any poisonous plant belonging

ing to the fifteenth class: they are generally called antiscorbutic. Those of the sixteenth, with many filaments, are mucilaginous and emollient. The seventeenth has no poisonous plant; but the seeds, which are food for men and other animals, are farinaceous and flatulent. Those of the nineteenth are chiefly bitter; and those of the twenty-fourth are mostly suspected or dangerous plants.

From the want of botanical knowledge, the grossest mistakes have been made in the application of the *English* names of *European* plants, to those of *America*. Many of our most common vegetables are generally known, and some of them frequently prescribed for medical purposes, by the names of plants that are entirely different, belonging to other classes, and possessed, no doubt, of different properties. Botanical enquiries will enable us to rectify these mistakes, and to distinguish the several species of *European* or other foreign plants from those that are peculiar to *America*.

We have it, also, in our power, from the recent settlement of the country, to determine, with great certainty, what vegetable productions are indigenous, and prevent those doubts and disputes hereafter, which have frequently taken place among botanists in old countries. For it is very improbable that any exotic plants are become so far naturalized as not to be distinguishable from the natives.

Was the theory of this science united with its practical uses, and employed in procuring the necessaries, and adding to the conveniences and ornaments of life, the vulgar opinion of its being merely speculative would be removed, and could not fail of engaging a more general attention. For it is well known that the economical uses of the vegetable kingdom are exceedingly

ingly numerous; not only furnishing food and medicine for man and beast, materials for agriculture, and various arts and manufactures; and for many of the *delights and ornaments* of life; but it supplies important articles of commerce, and, in some countries, is the greatest source of internal wealth. We are, no doubt, yet ignorant of many productions well adapted to most, or all, of these purposes.

The native Indians were acquainted with the peculiar properties of certain vegetable productions, which if thoroughly understood by the present inhabitants, might be made extensively useful, both in physic, arts and manufactures, and new branches of commerce. Their *materia medica* seems to have consisted of few articles: these were certain plants, powerful in their operation, and sometimes producing sudden and surprising effects upon the human body. These savages seem to have had better ideas of the medical virtues of plants, than some who have imagined that vegetables, fit only for food, were the most proper for medicine; and that combining a great number of the most common plants, might be a remedy for almost every disease. Vegetables called poisonous are capable of producing great and sudden alterations in the human body: May not many of them be found, upon accurate and well-judged experiments, like some chymical poisons, to be the best medicines? The Indians had discovered effectual antidotes against the venom of rattle-snakes, which must have been a discovery of great importance to them, and may, possibly, be reckoned among their greatest improvements in the knowledge of medicine. Mr. *Catesby* mentions a fact, which he says was well attested, of an Indian's daubing himself with the juice of the purple bindweed, a species of the convolvulus, and then handling a rattle-snake with his naked hands, without receiving any injury. The

These natives were, likewise, possessed of the art of dyeing deep and most permanent black, red and yellow colours. These colours were given to bone, horn, porcupine quills and other hard substances, which still appear, unimpaired, on some of their ornaments and utensils. The Spaniards are said to have procured from the *Californian* Indians, the art of dyeing the best black ever yet known. The plant they employ in this dye is called the *cascalote*, a small shrub, which abounds in that country, and may probably be found within the limits of the United States.

However desirable the knowledge of our vegetable productions may be, our progress must be slow, until men, versed in this science, can devote their time to the investigation of them. Some advances may be made by individuals collecting the productions of their own neighbourhood, and transmitting accounts of them, from time to time, to the Academy. How much a correspondence of this kind has done, in perfecting the history of the *British* plants, will appear from the numerous botanical papers published in the transactions of the Royal Society.

As there has never been a description given of the indigenous plants in this part of the country, and it being one of the ends of the institution of this Academy to promote the knowledge of natural history, I take the liberty of communicating an account of some of those which have fallen under my observation. They are arranged according to the *Linnean* system; and the generic characters, where they were found to correspond, are referred to *Linnaeus's* description in the fifth edition of his *Genera Plantarum*: The characters of the species, where there was an agreement, are taken from the tenth edition of the *Systema Naturæ*. A few synonyms from other authors are given, and more

more might have been added, had it been consistent with the limits of the paper. Some additional description of most of them, the times of flowering and places of growth, were thought necessary. Those plants which appear not to agree with the essential generic characters of any known genus, are inserted without any generic names, but the natural characters of the fructification are particularly described. Such as appeared doubtful are distinguished by a mark of interrogation. The *English* names are those by which the plants have been called either here or in other parts of the world, except, in a few instances, where no trivial name was known. The medical and oeconomic uses which are mentioned, are inserted from the best private information that could be obtained, or selected from good authorities; many of them, in particular, from a late ingenious and useful publication by *William Withering*, M. D. entitled, "The botanical arrangement of *British* plants."

In giving this account of indigenous plants, I have had opportunity of investigating only those which were found growing within the compass of a few miles; except a small number that happened to be noticed at a greater distance. Many others have been observed, but the limits of this paper did not admit their being inserted. The generic characters of these plants were minuted from fresh blossoms in full bloom, with the aid of a microscope, and with as much attention as the little leisure I have had for botanical enquiries would admit. But not having examined any of them, for any other purpose than mere amusement, until the last summer, I doubt not errors will be found in this arrangement, which more time and further examination might have prevented. This I hope will be admitted as some apology, by every experienced botanist, who

knows how much time is necessary for investigating and arranging a considerable number of plants in a part of the country never before explored.

Ipswich, January 26, 1784.

MONANDRIA.

MONOGRNIA.

SALICORNIA. Linn. Gen. Plant. 10.

Salicornia articulata apice compressis emarginatis bifidis. Syst. Nat. *Kali geniculatum annuum.* Park.

GLASSWORT. Saltwort. Marsh Samphire. The stem grows about eight or ten inches high: the main stem divides itself into numerous branches. It is found on the sea-shore. Blossoms in September.

In Europe a fossil alkali is obtained from the ashes of this plant, which is in great request for making glass and soap. It is said to make a pickle little inferior to samphire.

DIGRANIA.

BLITUM. Linn. Gen. Plant. 14.

Blitum capitellata spicata terminalibus. Syst. Nat. *Chenopodium morosum.* Boerh.

BLITE. Several stems rise from the same root, running into many short ramifications. Leaves oblong and obtuse. Blossoms extremely small; green with a yellow anthera. The smell is considerable, resembling Savin. About Parker-river bridge, in Newbury. August.

DIANDRIA.

MONOGRNIA.

LIGUSTRUM. Linn. Gen. Plant. 18.

PRIM. Privet. A shrub. Leaves in pairs. Blossoms white. Berries black. In Lynn. Not very common in a wild state. June. It

It makes excellent hedges. The berries, gathered as soon as they are ripe, dye wool and silk of a good and durable green, with the addition of alum.

CIRCÆA. Linn. Gen. Plant. 24.

Circæa caule adscendente, racemo unico. Syft. Nat.

ENCHANTERS NIGHTSHADE. Blossoms variegated. Among bushes in a moist, rich soil. July.

VERONICA. Linn. Gen. Plant. 25.

Veronica racemis lateralibus: pedicellis pendulis, foliis linearibus integerrimis. Syft. Nat.

PIMPERNEL. Brooklime. Water Speedwell. Blossoms whitish or purplish. In swamps. June—July.

Veronica.

ONE FLOWER. Stem somewhat procumbent. Leaves orbicular; opposite on short pedicles. Blossoms solitary, supported on short flower stalks rising from the *axillæ* of the leaves: they are small; white, striated with purple. By the way-side. May—July.

GOLDENPERT. The *calix* consists of one leaf; tubular. The limb deeply divided into five ovate, acuminate segments; with two small leaves growing on the outside of the cup, opposite the two upper sinuses. *Corolla* one petal; tube very long; angular; border divided into four circular, patent, emarginated segments; lapping. The upper segment largest: the lower smallest. *Stamina* two short filaments rising from the tube, near together, below the upper segment; shorter than the tube. *Antheræ* circular; flattish; adhering together. *Germen* ovate.

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Stile

Stile cylindrical; erect; of the length of the *Stamina*. *Stigma* concave; circular; bent downward. *Capsule* ovate; two cells; two valves. *Seeds* numerous; very small.

The stem round; erect. Leaves strap-shaped; opposite; entire. Blossoms single; on flower-stalks rising from the *axillæ* of the leaves; yellow. Around the shore of *Wenham* pond. August.

BASTARD-PEPPERGRASS. The *calix* consists of a perianthium of four erect, concave leaves; the margin coloured; two of them larger, which stand opposite. Deciduous. *Corolla* none. *Stamina* two subulated filaments with antheræ; stand opposite; of the length of the calix. *Antheræ* simple. There are four other shorter filaments without antheræ; one on each of the sides of the fertile filaments. *Germen* circular; compressed; emarginated. *Stile* very short. *Stigma* blunt and jagged. *Capsule* circular; compressed; emarginated; two cells; four valves. Two flat *seeds*; the edges tumid.

Stems round; branched. Radical leaves deeply indented; stem leaves lanceolate and slightly serrated. Blossoms very small; on fruit-stalks forming a long open spike at the extremities of the branches. Borders of fields. July—Sept.

UTRICULARIA. Linn. Gen. Plant. 29.

Utricularia nectario conico. Syft. Nat. *Lentibularia.* Ray. Syn. *Millefolium aquaticum flore luteo galericulato.* Park.

BLADDERWORT. Common hooded Milfoil. The roots are very small, swimming in the water, and seem scarcely to touch the ground. They send off numerous branched fibres, beset with small membranaceous bladders, appearing like black seeds. Blossoms yellow. Ponds with a muddy bottom. August.

Utricularia

Utricularia nectario carinato. Syst. Nat.

PURPLE BLADDERWORT. Lesser hooded Milfoil. The roots are jointed. Bladders less than the former species. Blossoms pale yellow. In muddy ponds. August.

VERBENA. Linn. Gen. Plant. 30.

Verbena diandra spicis longis, calicibus aristatis, foliis ovatis serratis. Syst. Nat.

VERVAIN. Simplers Joy. The stems are quadrangular. Leaves stand opposite. Blossoms in a long close spike; pale blue. Common by road-sides. July—Sept. There are two or three varieties of this species of the *Verbena* very common.

It is said that the Surgeons of the *American* army, at a certain period when a supply of medicine could not be obtained, substituted a species of the *Verbena* for an emetic and expectorant, and found its operation kind and beneficial.

LYCOPUS. Linn. Gen. Plant. 31.

Lycopus foliis æqualiter serratis. Syst. Nat.

WATER HOREHOUND. Gipsie. The stem four cornered. Leaves opposite. Blossoms whitish; surrounding the stem at the joints. Borders of meadows. August.

This plant has been mistaken for a species of the *Veronica*, and is generally known by the name of *Paul's Betony*. It is said the juice will give a permanent colour to linen, wool and silk, that will not wash out.

TRIANDRIA.

MONOGYNIA.

IRIS. Linn. Gen. Plant. 57.

Iris corollis imberbibus, germinibus trigonis, caule ancipiti. Syst. Nat.

BLUE-FLAG.

BLUE-FLAG. The leaves are sword-shaped. Blossoms blue variegated with white, yellow and purple. In wet meadows. June.

A decoction of the fresh roots is a powerful cathartic, and will sometimes produce evacuations when other means fail; but it is too drastic for common use. The juice of the fresh roots may be given in doses of 60 or 80 drops every two hours. Dr. *Withering* says the fresh roots of the yellow water flag have been mixed with food of swine bitten by a mad dog, and they escaped the disease, when others, bitten by the same dog, died raving mad. The root loses most of its acrimony by drying.

XYRIS? Linn. Gen. Plant 59.

YELLOWED-GRASS. The corolla consists of three ovate, patent, entire petals. The claws narrow; of the length of the calix. *Nectaria* three filiform filaments between the petals, longer than the calix, terminating in numerous long hairs. Three very short filaments rising from the petals in the mouth of the blossom. Capsule membranaceous; one cell; three valves; oblong; compressed on one side. The other parts agree with *Linnaeus's* description.

The stem flattish; naked; erect. Radical leaves narrow; tapering to a point. Blossoms in an head on the summit of the stem; bright yellow. On banks of ponds. August.

CYPERUS. Linn. Gen. Plant. 61.

Cyperus culmo triquetro, umbellæ spiculis capitatis oblongis sessilibus, involucris longissimis serrato-asperis? Syst. Nat.

GALANGALE. In open swamps. August.

SCIRPUS. Linn. Gen. Plant. 62.

Scirpus culmo tereti nudo, spicis ovatis pluribus pedunculatis terminalibus. Syst. Nat.

BULLRUSH.

BULLRUSH. In ponds and rivers. August.

When properly cured it makes very neat bottoms to chairs ; but they will be much stronger mixed with the leaves of the cat's tail flag, though somewhat coarser.

Scirpus culmo triquetro nudo acuminato, panicula spicis conglomerata laterali. Syft. Nat.

THREE CORNERED RUSH. Banks of ponds and rivers. Aug.

ERIOPHORUM. Linn. Gen. Plant. 63.

Eriophorum culmis foliosis teretibus, foliis planis, spica erecta. Syft. Nat. *Gramen juncoides lanatum alterum danicum.* Park.

COTTONGRASS. Puffy. Mossy meadows. May.

The down of the heads has been used for stuffing pillows and making wicks of candles.

The indigenous grasses of the second order are numerous, but the limits of this paper would not admit of their being inserted. A description of these and other native grasses may be the subject of another paper.

TRIGYNIA.

MOLLUGO. Linn. Gen. Plant. 99.

Mollugo foliis verticillatis cuneiformibus acutis, caule subdiviso decumbente, pedunculis unifloris. Syft. Nat. *Mullugo foliis saepius septenis lanceolatis.* Gronov.

CARPET-WEED. Stem divided into numerous branches, spreading on the ground. Blossoms greenish white ; in clusters at the joints. About pathways. July.

TETRANDRIA.

MONOGYNIA.

ARUM Americanum, beta folia. Cat. Arb. Nat. Hist.

SCUNK CABBAGE. Scunkweed. The calix consists of a very large, permanent *Spatha* ; of a thick, porous substance, approaching

proaching to an ovate form; open on one side, and bellied out on the opposite; the margin auriculated at the base, and somewhat twisted at the apex. The *Spadix* within the *Spatha*. The florets numerous, placed around the receptacle in an oval form; and are so compact as to appear like a solid body, thick set with small, regular protuberances on its surface. No *Calix*. *Corolla* four erect, very thick, narrow, obtruncated petals. *Stamina* four flattish filaments rising from the receptacle; longer than the corolla. *Antheræ* oblong. *Germen* convex. *Stile* cylindrical; rather longer than the stamina. *Stigma* bifid. *Seeds* large; roundish; single; inclosed within the receptacle.

The first appearance of this singular plant is the flower. After the flower is arrived to a state of perfection, the leaves appear at a small distance from the flower stalk, in a conic form, very closely rolled together. As they rise they expand; nearly ovate; supported on foot stalks. The plant has no stem. The globe of flowers is nearly of the colour of the spatha, which is beautifully variegated with scarlet and yellow. Common in swamps and borders of meadows. April—May.

This plant, which is found native no where but in *North-America*, has been considered by botanists as a species of the *Arum*. But the florets are hermaphrodite, having each of them distinct and perfect corolla, stamina and pistil. It therefore belongs to the first order of this class, and is to be arranged among the aggregate flowers with a common perianthium. The fructification so essentially differs from all the genera of this order, it must, undoubtedly, be considered as a new genus. The vulgar name, by which it is, here, generally known, is taken from its very rank and disagreeable smell, nearly resembling that of a scunk or polecat.

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The roots dried and powdered are an excellent medicine in asthmatic cases, and often give relief when other means are ineffectual. It may be given with safety to children as well as to adults; to the former, in doses of four, five or six grains, and to the latter, in doses of twenty grains and upwards. It is given in the fit, and repeated as the case may require. This knowledge is said to have been obtained from the Indians, who, it is likewise said, repeat the dose after the paroxysm is gone off, several mornings, then miss as many, and repeat it again; thus continuing the medicine until the patient is perfectly recovered. It appears to be antispasmodic, and bids fair to be useful in many other disorders. In collecting the roots particular care ought to be taken that the *white hellebore*, or *poke root*, which some people call *scunk weed*, be not mistaken for this plant, as the consequence might be fatal. There is an obvious distinction—the hellebore has a stalk, but the scunk cabbage has none.

CEPHALANTHUS. Linn. Gen. Plant. 105.

Cephalanthus foliis oppositis ternisque. Syft. Nat.

GLOBE-FLOWER SHRUB. Pond Dogwood. Button Bush. The florets form a perfect globe, and when the fruit stalk is separated it does not readily appear in what part of the globe it was inserted. The blossoms are snow-white, fragrant and beautiful when in full bloom. Common in watery swamps and pond-holes. July—August.

HEDYOTIS. Linn. Gen. Plant. 110.

Hedyotis foliis lineari-lanceolatis, caule herbaceo dichotomo, pedunculis geminis. Syft. Nat.

VENUS PRIDE. Blossoms white or bluish. It spreads over pastures and fields, in large beds, and gives them a white appearance. May—June.

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MITCHELLA.

MITCHELLA. Linn. Gen. Plant. 126.

PARTRIDGEBERRY. The stems trailing. Leaves orbicular-cordate ; opposite, with large white veins. Blossoms white. In thick woods and swamps. June—July.

PLANTAGO. Linn. Gen. Plant. 133.
Plantago, foliis ovatis glabris, scapo tereti, spica flosculis imbricatis. Syst. Nat.

PLANTAIN. Common near roads and foot-paths. June—July.

The leaves are applied, by the common people, to inflamed fores and swellings. The bruised leaves they apply to fresh cuts.

Plantago foliis lanceolato-ovatis pubescentibus subdenticulatis, spicis laxis pubescentibus, scapo angulato. Syst. Nat.

VIRGINIA PLANTAIN. In grass land. Not common. May—June.

Plantago foliis semicylindraceutis integerrimis basi lanatis, scapo tereti. Syst. Nat.

SEA PLANTAIN. In salt marshes. July.

It is said to be cultivated and sown with clover in North-Wales in Great-Britain, and greedily eaten by horses and cows: but Linnæus says, that cows are not fond of it.

SANGUISORBA. Linn. Gen. Plant. 136.

Sanguisorba spicis longissimis. Syst. Nat. *Pimpinella maxima.* Cornutus.

AMERICAN BURNET. *Snakeweed.* The leaves are winged ; very long. The small leaves serrated. The filaments and antheræ are white. In rich moist ground. July—September.

Its

Its growth is generally luxuriant, and makes good fodder for cattle.

CISSUS. Linn. Gen. Plant. 137.

Cissus foliis ovatis nudis setaceo—serratis. Syft. Nat.

PIGEON-BERRY BUSH. The shrub grows six or eight feet high. Leaves opposite. Blossoms in broad-topped spikes; white. Common on the banks of brooks and rivers. June.

Pigeons feed on the berries, which has been the occasion of its trivial name.

MEADOW BLUEBELLS. The *calix* is a permanent perianthium of one leaf; tubular. Tube quadrangular; limb divided into four acute, erect segments. The *corolla* one petal. Tube between funnel and bell-shaped; longer than the calix; divided into four roundish, patent segments, with ciliated margins. *Nectaria* four prominent glands in the base of the corolla. *Stamina* four triangular, erect filaments; inserted into the corolla, and of the length of the calix. *Antheræ* oblong; erect. *Germen* oblong; within the tube. *Stile* short. *Stigma* bifid; flat; circular. *Capsule* oblong, quadrangular; one cell; four valves. *Seeds* numerous; ovate; adhering to the angles of the capsule.

The stem nearly round; erect; branched. Leaves ovate; opposite; half embracing the stem. Blossoms large; single; terminating; bright blue. In moist land. Not common. September.

The blossoms open about ten o'clock in the morning, and close by two in the afternoon.

CORNUS. Linn. Gen. Plant. 139

Cornus herbacea, ramis nullis. Syft. Nat.

CORNEL. *Dogberry.* The stem is quadrangular. Leaves oval; opposite. From the *axilla* of the upper leaves, two other leaves are sent off, spreading laterally, which give the appearance of six leaves at a joint. Blossoms white. In woodland. May—June.

OLDENLANDIA. Linn. Gen. Plant. 143.

DOGWOOD. The leaves are ovate; acuminate. Blossoms in broad-topped spikes; white. In swamps and banks of rivers. July.

DIGRANIA.

HAMAMELIS. Linn. Gen. Plant. 155.

WITCH-HAZEL. The leaves are nearly inversely ovate. Blossoms yellow: stand three or four together on short flower stalks. In loamy land. Sept.—October.

This singular shrub does not commonly bloom until its leaves are destroyed by frost, when its numerous blossoms make a gay and agreeable appearance; and continue until the weather becomes very cold, often until snow falls. The germen endures the severity of our winters uninjured; for the fruit does not ripen until the next September, the time of its blossoming again, when ripe fruit and blossoms will be found on the same tree.

The Indians considered this tree as a valuable article in their *materia medica*. They applied the bark, which is sedative and discutient, to painful tumors and external inflammations. A cataplasm of the inner rind of the bark, is found to be very efficacious in removing painful inflammations of the eyes. The bark chewed in the mouth is, at first, somewhat bitter, very sensibly astringent, and then leaves a pungent, sweetish taste, which will remain for a considerable time. The specific qualities

lities of this tree seem, by no means, to be accurately ascertained. It is, probably, possessed of very valuable properties.

CUSCUTA. Linn. Gen. Plant. 156.

Cuscuta floribus pedunculatis. Syft. Nat.

DODER. Devil's Guts. Among flax. July.

This plant is well known to farmers, who often have their fields of flax greatly injured by its twining about the stalks. It is parasitical. When it has ascended the stalk of flax, or whatever plant is next to it, a number of very small papillæ are sent off from the inner surface of the vine, which insinuate themselves into the bark of the plant. The root then decays, and it receives its nourishment from the plant which it twines about. The whole plant is bitter; and it affords a pale reddish colour.

TRAILING COCKSPUR. *Calix* none; except the corolla be called the calix. *Corolla* one petal; flat; coloured without and within. Limb deeply divided into four ovate acuminate segments. Deciduous. *Stamina* four short, filiform, erect filaments; standing upon the corolla. *Antheræ* globular. *Ger-men* below; double. *Stiles* two; erect; passing through the base of the corolla. *Stigmata* globular. Two seeds, or nuts, contained in a rind thick set with hooked spines.

The generic characters of this plant approach those of the *Aphanes*, but seem so essentially to differ as not to admit its being placed under that genus.

The stem trailing; four square; the edges tumid, and beset with short, hooked spines. Leaves lanceolate; fix at a joint. Blossoms reddish white; placed in the *axillæ* of the leaves. Borders of brooks and ditches. August.

UPRIGHT

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UPRIGHT COCKSPUR. Stems erect; quadrangular. Leaves ovate; four at a joint. Stem-leaves rough: somewhat woolly. Blossoms white. Open wood land. June.

TETRAGYNIA.

POTAMOGETON. Linn. Gen. Plant. 160.

Potamogeton foliis oblongo-ovatis petiolatis natantibus. Syft. Nat. *Fontalis major latifolia vulgaris.* Park.

PONDWEED. Blossoms in spikes; yellowish. In ponds and rivers. August.

The leaves afford an agreeable shade to pickerel.

PENTANDRIA.

MONOORNIA.

CYNOGLOSSUM. Linn. Gen. Plant. 168.

Cynoglossum flaminibus corolla brevioribus, foliis lato—lanceolatis tomentosis sessilibus. Syft. Nat.

HOUNDSTONGUE. Blossoms pale blue. Road sides in Dedham. July.

It has a very disagreeable smell. Dr. Withering observes, that both the root and leaves have been suspected to possess narcotic properties; but that others will not admit the fact.

SYMPHYTUM. Linn. Gen. Plant. 170.

Symphytum foliis ovato—lanceolatis decurrentibus. Syft. Nat. *Symphytum magnum.* Raii. Syn.

COMFREY. Blossoms yellowish white. In moist land. Not common growing wild. June.

It is cultivated in gardens; and though it is sometimes found growing wild, there seems to be some doubt whether it be indigenous.

The

The roots are much used by the common people for sprains. They are glutinous and mucilaginous. The leaves give a grateful flavour to cakes and panadoes.

CORTUSA. Linn. Gen. Plant. 181.

Cortusa calycibus corollam excedentibus. Syft. Nat.

BEARSEAR SANICLE. The stems are round; erect. Leaves oblong in pairs. Blossoms yellow. In moist ground. July.

HOTTONIA. Linn. Gen. Plant. 186.

Hottonia pedunculis verticillato—multifloris. Syft. Nat. *Mil-lesfolium aquaticum floridum seu viola aquatica.* Park. *Hottonia.* Boerh.

WATER VIOLET. Featherfoil. Leaves winged, spreading on the surface of the water in a stellate form. Blossoms white. In standing waters and ditches. May—June.

LYSIMACHIA. Linn. Gen. Plant. 188.

Lysimachia foliis quaternis subsessilibus, pedunculis quaternis unifloris. Syft. Nat.

YELLOW WILLOWHERB. Pimpernel. Loofestriſe. Stem round; hairy. Leaves ovate. Blossoms bright yellow. In wood land. June.

MEADOWSWEET. Moneywort. Stems erect. Leaves oblong; five or six at a joint; marked with white or red specks. Blossoms single; on long flower stalks; yellow. Borders of meadows, or brooks. June.

ANAGALLIS. Linn. Gen. Plant. 189.

Anagallis foliis indivisis, caule procumbente. Syft. Nat.

Anagallis flore phæniceo. Park.

PIMPERNEL. Blossoms red. In clayey ground. June.

Anagallis

Anagallis foliis sinuatis. Syft. Nat.

GROUNDSTAR. Blossoms white, tinged with red. Amongst
grafs by the way side. May—Aug.

AZALEA. Linn. Gen. Plant. 195.

Azalea foliis ovatis, corollis pilosis, staminibus longissimis. Syft.
Nat.

AMERICAN HONEYSUCKLE. *Swamp Pink.* Blossoms in a
kind of tuft at the termination of the branches. They are
white; but the deep red globules at the ends of the hairs on
the corolla and stamina give the appearance of a red tinge.
Common in low, swampy land. June.

This shrub, when in full bloom, makes an elegant appear-
ance. The blossoms are fragrant, and have been made into
conerves. It is easily propagated in gardens, and may doubt-
less be improved by cultivation. We have few exotic flower-
ing shrubs superior to it.

CONVOLVULUS. Linn. Gen. Plant. 198.

*Convolvulus foliis sagittatis utrinque acutis, pedunculis uni-
floris.* Syft. Nat.

BINDWEED. *Small Convolvulus.* Blossoms white or striped.
In corn fields. July.

*Convolvulus foliis sagittatis postice truncatis, pedunculis tetra-
gonis unifloris.* Syft. Nat. *Convolvulus major albus.* Park.

GREAT CONVULVULUS. Two floral leaves close to the calix.
Blossoms white; or white and red. Common in hedges, and
by stone walls. July.

Catesby, in his history of the *Carolinas*, mentions an Indian who
daubed himself with the juice of a species of the *Convolvulus*,
and then handled a rattle-snake without receiving injury.

Scammony.

Scammony, Dr. *Withering* says, is the inspissated juice of a species of *Convolvulus* so much resembling this, that they are with difficulty distinguished. Can it then, says he, be worth while to import Scammony from *Aleppo*, at a considerable annual expence, when a medicine, with the very same properties, grows spontaneously in many of our hedges? If the preparation of Scammony would be a saving to *England*, it must certainly be a much greater to *America*, in proportion to the quantity used. Besides, as the imported Scammony is often very impure, and as there is so much difference in the purgative virtue of some masses of it, and that of others, that it is seldom to be depended upon alone in extemporaneous practice, might it not be prepared here much purer, and be more uniform in its virtue? Notwithstanding the roots of the *Convolvulus* is a very acrid purgative to the human race, hogs will eat it in large quantities without any ill effects.

IPOMOEAE. Linn. Gen. Plant. 199.

Ipomoea foliis cordatis integerrimis glabris lacunosis, pedunculis bifloris. Syst. Nat.

AMERICAN JASMINE. Leaves stand opposite. Blossoms yellow, tinged with red. Among hazel bushes. Very rare. July.

AMERICAN TEA. The calix a very small permanent rim, surrounding the receptacle; scarcely visible. Corolla one petal; tubular. Limb divided into five acuminate segments; rolled inward. Nectaria five hooded petals, with long, filiform claws, inserted into the corolla below the sinuses of the segments; erect; longer than the segments of the corolla. Stamina five subulate filaments standing upon the corolla just

below

E e e

below

below the petals of the nectarium. Antheræ globular; covered by the hooded petals of the nectarium. Germen above; globular. Stile cylindrical; erect; shorter than the stamina. Stigma trifid. Capsules three; each one cell; one valve. Seeds one in each cell; ovate compressed.

Stems woody. Leaves ovate; serrated; acuminate. Blossoms in long, terminating, open spikes; snow white. By fences, and among bushes in loamy land. July.

The leaves of this shrub have been much used by the common people, in some parts of the country, in the room of India tea; and is, perhaps, the best substitute the country affords. They immerse the fresh leaves in a boiling decoction of the leaves and branches of the same shrub, and then dry them with a gentle heat. The tea, when the leaves are cured in this way, has an agreeable taste, and leaves a roughness on the tongue somewhat resembling that of the bohea tea.

CAMPANULA? Linn. Gen. Plant. 201.

Campanula foliis subovatis integerrimis, caulibus diffusis. Syft. Nat.

VENUS LOOKING-GLASS. Blossoms yellow. On high land. July.

PHYTEUMA. Linn. Gen. Plant. 203.

Phyteuma capitulo subfolioso, foliis omnibus lanceolatis. Syft. Nat.

RAMPION. Blossoms white with blue veins. Moist land. July.

LONICERA. Linn. Gen. Plant. 210.

Lonicera racemis terminalibus, foliis serratis. Syft. Nat.

HONERSUCKLE. Bastard Cherry. Blossoms yellow, tinged with red. Among bushes in loamy land. June.

VERBASCUM.

VERBASCUM. Linn. Gen. Plant. 217.

Verbascum foliis decurrentibus utrinque tomentosis. Syft. Nat.

MULLEIN. Blossoms in long terminating spikes; yellow. Common in old fields. July.

Verbascum foliis amplexicaulibus oblongis glabris, pedunculis solitariis. Syft. Nat.

MOTH MULLEIN. Blossoms yellowish white. By the road sides in Lynn. July.

DATURA. Linn. Gen. Plant. 218.

Datura pericarpis spinosis erectis ovatis. Syft. Nat.

APPLEPERU. Stramonium. Thornapple. Blossoms white with a tinge of purple. The upper leaves have been observed to rise up and enclose the blossoms at night. Common by the way sides. August.

This plant is said to be an exotic, and that it is not found growing at any great distance from the sea. The seeds taken internally bring on delirium; large doses would, no doubt, prove fatal. The leaves applied to the feet, or part affected, have been found efficacious in removing spasms; and applied in cataplasms give ease in external inflammations. An ointment prepared from the leaves gives ease likewise in external inflammations and hæmorrhoids. The *Edinburgh* College direct an extract to be prepared by evaporating the expressed juice of the leaves. Its medical properties undoubtedly merit attention. None of the herbivorous animals will eat it.

HYOSCYAMUS. Linn. Gen. Plant. 219.

Hyoscyamus foliis amplexicaulibus. Syft. Nat.

HENBANE. Blossoms purple and brown; clammy. Common amongst rubbish, and by road sides. July.

The seeds, the leaves, and the roots, Dr. *Withering* observes, are all poisonous. Madness, convulsions, and death, are the general consequence. In a smaller dose, they occasion giddiness and stupor. The *Edinburgh* College order the expressed juice of the plant to be evaporated to an extract. In this state, the Doctor supposes, it may be advantageously joined with opium, where the effects of that medicine are desirable, and costiveness is to be avoided. There is no doubt, he says, of its being a useful medicine under proper management. The dose is from half a scruple to half a dram. It is said, that the leaves scattered about a house will drive away mice.

SOLANUM. Linn. Gen. Plant. 224.

Solanum caule inermi frutescente flexuoso, foliis superioribus hastatis, racemis cymosis. Syst. Nat.

BITTER-SWEET. Blossoms purple, with spots of white. Common about fences in moist land. June.

Boerhaave says, it is a medicine far superior to China and Sarsaparilla as a sweetner and restorative. *Linnæus* says, an infusion of the young twigs is an admirable medicine in acute rheumatisms, inflammations, fevers, and suppression of the lochia. Dr. *Hill* says, he has found it very efficacious in the asthma.

Solanum caule inermi herbaceo, foliis ovatis dentato—angulatis, umbellis nautantibus. Syst. Nat.

NIGHTSHADE. Blossoms white. Berries black. Common among rubbish. July.

Dr. *Withering* says, from one to three grains of the leaves infused in boiling water, and taken at bed time, occasions a copious perspiration; increases secretions by the kidneys, and generally

generally purges more or less the following day. These properties, judiciously applied, render it capable of doing essential service in several diseases. But its effects on the nervous system are so uncertain, and sometimes so considerable, that it must ever be administered with the greatest caution. The leaves applied externally, ease pain and abate inflammations.

TIVERTWIG. *American Mezerion.* The generic characters do not entirely agree with the *Solanum*; but they approach nearer to this than any other genus. Stems woody; twining about shrubs or trees; branched. Leaves ovate; serrated; acuminate. Blossoms greenish white. Berry pale red. In hedges and wood land. June.

It is used with success in discharging indurated tumors. Farmers apply it to swellings in cows bags. Physicians of distinguished characters say, that the roots answer as valuable a purpose, in venereal cases, as the *Mezerion*.

RIBES. Linn: Gen. Plant. 247.

Ribes inerme, racemis pilosis, floribus oblongis. Syst. Nat.

BLACK CURRANT. Blossoms yellowish. Berries black. It is rarely found growing naturally here, but is cultivated in gardens. In some parts of the eastern country it is said to be found in great plenty, particularly near *Kennebeck-river*.

A jelly made of the fruit is celebrated in the Philosophical Transactions of the Royal Society for curing very bad kinds of sore throat. It has been found to answer very well here, particularly in that species of the sore throat in which the tonsils suppurate. It ought to be applied early and frequently. When the fruit could not be obtained, an infusion of the bark, sweetened with honey, and used as a gargle, has proved beneficial.

Dr.

Dr. *Withering* says, the juice of the berries is frequently boiled down into an extract, with the addition of a small proportion of sugar, which is called rob, and is much used in sore throats, but chiefly in those of the inflammatory kind. An infusion of the young roots is useful in fevers of the eruptive kind; and in the dysenteric fevers of cattle. The fruit is often put into rum instead of black cherries. The tender leaves will give a tinge to rum nearly resembling brandy.

Ribes ramis aculeatis, petiolorum ciliis pilosis, baccis hirsutis.
Syst. Nat.

GOOSE BERRY. Blossoms greenish white. Berries redish, or white. Common in moist hedges, and banks of ditches. May.

The fruit is very agreeable, either as nature presents it, or made into a jelly. It is much used in tarts. An equal weight of picked Goose Berries and pure sugar put over the fire, will spontaneously separate a liquor which becomes a most agreeable jelly. The fruit of the wild Goose Berry may be greatly improved by cultivation.

HEDERA. Linn. Gen. Plant. 249.

Hedera foliis ovatis lobatisque. Syst. Nat. *Hedera trifolia Canadensis.* Corn.

POISON IVY. Blossoms white, with purple or black veins. Berries black. Common in moist hedges and meadows. June.

It ascends trees adhering by numerous linear tendrils, which are sent off from the body of the stem, insinuating their sharp ends into the bark of the tree. It produces the same kind of inflammations and eruptions, in certain constitutions, as the poison wood tree. A milky juice exudes from the stalks and leaves,

leaves, which will stain linen a deep and unfading black. This juice is said to have been used by the Indians in staining the hardest substances a deep and permanent black. Country people employ it in making ink. Some have supposed its properties are not inferior to those of the Japan varnish tree.—It is undoubtedly worthy of attention.

Hedera foliis quinatis ovatis serratis. Syft. Nat.

WOODBINE. Ivy. Blossoms greenish white. Berries dark brown. Moist wood land. July.

It is planted by walls and buildings, upon which it will ascend, supporting itself by a singular kind of degitate tendrils.

VITIS. Linn. Gen. Plant. 250.

Vitis foliis cordatis dentato—serratis utrinque nudis Syft. Nat.

GRAPE. Blossoms white. Berries white or purple. Common in moist land, and swamps.

DIGYNIA.

APOCYNUM. Linn. Gen. Plant. 269.

Apocynum caule rectiusculo herbaceo, foliis ovatis utrinque glabris, cymis terminalibus. Syft. Nat.

DOGSBANE. Umbrella weed. Blossoms white, striped with red. Borders of wood land. July.

Apocynum caule erecto frutescente, foliis lanceolato—ovalibus, corollis acutis: fauce villosis. Syft. Nat.

RIVER SWALLOWWORT. Blossoms yellowish white. At Winnepesocket-falls, in Providence-river. July.

ASCLEPIAS. Linn. Gen. Plant. 270.

Asclepias foliis lanceolato—ellipticis, caule simplici glabro, nectarii corniculis conniventibus. Syft. Nat.

SILKWEED.

SILKWEED. Blossoms redish. Common by the road sides, and in pastures. July.

The seeds are contained in large pods, and are crowned with white down, extremely fine and soft, resembling filk, which has occasioned the name of Silkweed. It may be carded and spun into an even thread, which makes excellent wickyarn. The candles will burn equally free, and afford a clearer light than those made of cotton wicks. They will not require so frequent snuffing, and the smoke of the snuff is less offensive. The texture of the down is weak, but sufficiently strong for dipped candles. If greater strength should be necessary, a small quantity of cotton wool may be mixed with the down. Large quantities may be easily collected, and the tallow-chandlers might, doubtless, be supplied for less than half the price of cotton yarn.

Asclepias foliis ovatis subtus villosis, caule simplici, umbellis erectis, nectariis resupinatis. Syst. Nat.

INDIAN HEMP. Blossoms redish. In moist land. July.

The fibres of the bark are strong, and capable of being wrought into a fine soft thread; but it is very difficult to separate the bark from the stalk. It is said to have been used by the Indians for bow-strings.

Asclepias foliis lanceolatis glabris, caule simplici, umbellis erectis lateralibus solitariis. Syst. Nat.

SWALLOWWORT. Blossoms white. About fences in moist land. July.

Asclepias foliis lanceolatis, caule superne diviso, umbellis terminalibus congestis. Syst. Nat.

MONEYWORT. Blossoms purple. In old fields. July.

CHENOPODIUM.

CHENOPODIUM. Linn. Gen. Plant. 273.

Chenopodium foliis ovatis dentatis acutis, racemis ramosis nudis.
Syst. Nat.

SOWBANE. Fruit green or reddish. About barns. August.

SALSOLA. Linn. Gen. Plant. 275.

Salsola herbacea decumbens, foliis subulatis spinosis scabris, calycibus marginatis axillaribus. Syst. Nat.

KELPWORT. Blossoms greenish. On the sea shore. September.

Salsola herbacea erecta, foliis subulatis spinosis lævibus, calycibus ovatis. Syst. Nat.

GLASSWORT. Blossoms greenish. On the sea shore. July.

ULMUS. Linn. Gen. Plant. 281.

Ulmus foliis duplicato-ferratis : basi inæqualibus. Syst. Nat.

ELM. Blossoms in broad-topped spikes. Bark of the trunk cracked and rough. In loamy land. April.

A decoction of the inner bark, drank freely, is said to carry off the water in dropsies. The bark dried and ground to powder, hath been mixed with meal, in Norway, to make bread in times of scarcity.

Ulmus foliis æqualiter ferratis : basi inæqualibus. Syst. Nat.

SMALL ELM. Common in moist land and swamps.

GOLDEN VINE. Calix a perianthium with five small, obtuse segments. Corolla one petal ; bell-shaped. Limb divided into five obtuse, patent segments. Stamina five erect filaments inserted into the corolla at the sinuses of the segments. Antheræ

F f f

simple.

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simple. *Germen* large ; globular. *Stiles* two ; very short. *Stigmata* simple. *Capsule* globular ; two cells ; four valves. *Seeds* two ; globular.

The stem is of the size of a pack-thread ; twining. It is parasitical ; attaching itself to whatever vegetable is next to it, by numerous papillæ. It has many branches. No leaves. Blossoms in bunches ; placed in the *axillæ* of the branches ; snow white. Common in hedges, and among bushes in moist ground. July.

SANICULA. Linn. Gen. Plant. 289.

Sanicula foliis radicalibus compositis : foliolis ovatis. Syft. Nat.

SANICLE. Blossoms greenish. By stone walls, and among bushes. June.

LASERPITIUM. Linn. Gen. Plant. 306.

LasERPitium foliolis trilobis incis. Syft. Nat.

GREAT LASERWORT. *Wild Angelica.* Blossoms white. On high land. Not common. June.

ANGELICA. Linn. Gen. Plant. 309.

Angelica foliis æqualibus ovatis inciso—serratis. Syft. Nat.

ANGELICA. American Masterwort. Blossoms greenish white. Borders of fields in moist land. July.

It is warm, acrid and aromatic. The stems are frequently candied by the country people.

SIUM. Linn. Gen. Plant. 310.

Sium foliis pinnatis, umbellis terminalibus. Syft. Nat.

WILD PARSLET. *Water parsnip.* Blossoms white. In watery places. July.

TRIGYNIA.

TRIGYNIA.

RHUS. Linn. Gen. Plant. 331.

Rhus foliis pinnatis ovatis acuminatis serratis subtus tomentosis.
Syst. Nat.

HAIRY SUMACH. Blossoms greenish white. Fruit scarlet.
About fields. July.

Rhus foliis pinnatis serratis lanceolatis utrinque nudis. Syst.
Nat.

VELVET SUMACH. Blossoms greenish white. Fruit in
large, ovate, close panicles; crimson. Common in a loamy
soil. July.

Rhus foliis pinnatis integerrimis, petiolo membranaceo articulato.
Syst. Nat.

DWARF SUMACH. Blossoms greenish white. Panicles open.
Fruit pale red. In rocky ground. July.

These species of Sumach are moderately astringent. An infusion of the berries, sweetened with honey, is sometimes used for a gargle in sore throats, and for cleansing the mouth in putrid fevers. The country people employ them in several kinds of dyes. With copperas or vitriol they give a good black; but it soon grows rusty. They are used in the preparation of Morocco and other leather. Carver says, the Indians, in order to render their tobacco more agreeable in smoking, mix with it equal quantities of the leaves of Sumach.

Rhus foliis pinnatis integerrimis, petiolo integro. Syst. Nat.
Arbor Americana alatis foliis succo venenato. Plukenet. *Toxicodendron foliis alatis, fructu purpureo pyriformi sparsis.* Catesby.

POISON WOOD. Swamp Sumach. Blossoms whitish. Panicles open. Fruit yellowish; small; pair-shaped. Common in swamps. June.

The milky juice stains linen a dark brown. The whole shrub is, in a high degree, poisonous to certain constitutions. The poison will be communicated by touching or smelling any part of the shrub. In about forty-eight hours inflammation appears on the surface of the skin, in large blotches; principally on the extremities, and on the glandulous parts of the body. Soon after, small pustules rise in the inflamed parts, and fill with watery matter, attended with very considerable burning and itching. In two or three days the eruptions suppurate; after which the inflammation subsides, and the ulcers heal in a short time. It operates, however, somewhat differently in different constitutions; and what is singular, some constitutions are incapable of being poisoned with it at all. It has been observed, that persons of irritable habits are the most liable to receive it.

Rhus foliis ternatis: foliolis petiolatis ovatis nudis integerrimis, caule radicante. Syst. Nat.

CREeping IVY. Blossoms whitish. In meadows. June.

The juice will stain linen a deep black. It is less poisonous than the Poison Wood.

The Abbé Sauvages stained linen a black colour with the juice of the *Toxicodendron Carolinæ* foliis pinnatis, floribus minimis herbaceis, which it retained, notwithstanding a great number of washings in lye. The juice adhered, without the least acrimony, to the cloth, with more force than any other known preparation. The Abbé Mazeas made trial of the juice of the *Hedera trifolia Canadensis*. Corn. The instant, he says, the cloth was exposed to the sun, it became the finest black he had ever seen. It was put into a boil of soap, and after being dried,

dried, into a strong lye of ashes, but neither of them made the least alteration. Mr. Philip Miller says, the *American Toxicodendron*, with the juice of which the Abbé Sauvages stained his linen, is the same species of plant from which the inhabitants of *Japan* procure the varnish with which they stain all their utensils : and recommends it to the inhabitants of the (then) *American* colonies to collect this varnish, which, he says, may not only produce much profit to themselves, but also become a national advantage. But Mr. John Ellis insists upon there being a difference in their specific characters. [*Philos. Transf. Royal Society. Vol. xlix. p. 157, 161, 866.*]

The leaves of some of our Poison Wood trees are entirely similar to Dr. Kämpfer's figure of the *Sitz*, vel *Sitz dsju*, vulgo *urus seu urus noki*. *Arbor vernicifera legitima folio pinnato, Juglandis fructu, recemoso Ciceris facie* : and the only difference between the leaf of one species of our Sumach and the leaf of the varnish tree, raised from seeds sent to the Royal Society, is, that the middle part, and not the base of the leaf of Sumach, is serrated. Considering the great profits that have accrued from the varnish tree, to the two large empires of *China* and *Japan*, and the advantages of a deep, permanent and incorrosive black dye, it must be thought worth while to make experiments on all our species of the *Hedera* and *Rhus*. If we should fail of success with respect to the native plants, there can be no doubt but that the varnish tree of *Japan*, could the seeds be procured in a vegetative state, would flourish in *America*.

VIBURNUM. Linn. Gen. Plant. 332.

Viburnum foliis cordatis serratis venosis subtus tomentosis.
Syst. Nat.

MEALTREE.

MEALTREE. Blossoms white. Berries black. In moist wood land. June.

Viburnum foliis lobatis, petiolis glandulosis. Syft. Nat.

WATER ELDER. Blossoms white. Berries red. In Gloucester, in wet land. June.

CASSINE? Linn. Gen. Plant. 333.

Cassine foliis oblongis serratis. Syft. Nat.

WINTERBERRY. The number of filaments is from five to seven, and the number of seeds equal to the number of filaments. Blossoms white. Berries red, and generally remain on the shrub through the winter. In swamps. June.

SAMBUCUS. Linn. Gen. Plant. 334.

Sambucus cymis quinquepartitis, caule arboreo. Syft. Nat.

ELDER. Blossoms white. Berries black. In swamps, and moist land. May.

Dr. *Withering* observes, that the inner green bark is purgative, and may be used with advantage where acrid purgatives are requisite. In small doses it is diuretic, and hath done eminent service in obstinate glandular obstructions, and in dropies. If sheep that have the rot are placed in a situation where they can get at the bark and the young shoots, they will soon cure themselves. The leaves are purgative like the bark, but more nauseous. The inner bark and leaves are ingredients in several cooling ointments. A decoction of the flowers, taken internally, is said to promote expectoration in pleurifies. If the flowers are fresh gathered, they loosen the belly. Externally, they are used in fomentations to ease pain and abate inflammation. They will give a flavour to vinegar. A rob prepared from the berries

berries is a gentle opener, and promotes perspiration. An infusion of the dried berries is given to children. The flowers kill turkeys, and the berries are poisonous to poultry. The fresh leaves laid round young cucumbers, melons or cabbages, are a good preservative against worms and insects. It is said, if turnips, cabbages, fruit trees or corn, (which are subject to blights from a variety of insects) are whipped with the green leaves and branches of Elder, the insects will not attack them. The green leaves are said to drive away mice.

ALSINE. Linn. Gen. Plant. 342.

Alsine petalis bipartitis, foliis ovato—cordatis. Syft. Nat.

CHICKWEED. Leaves opposite. Blossoms white; open about nine in the morning, and close at noon. Common in gardens, and rich cultivated ground. June—September.

If it be boiled when young, it can hardly be distinguished from spring spinach. What is called the sleep of plants is very apparent in the Chickweed. At night the leaves approach, in pairs, so near as to inclose, within their upper surface, the rudiments of the young shoots and the ends of the branches. As the dew goes off in the morning they expand.

PENTAGYNIA.

ARALIA. Linn. Gen. Plant. 346.

Aralia caule petiolisque aculeata, foliolis inermibus villosis. Syft. Nat.

BERRY-BEARING ANGELICA. Shot Bush. Pigeon Weed. Blossoms white. Berries black. Common in new plantations. July.

Aralia caule folioso herbaceo lævi. Syft. Nat.

PETTYMORREL.

PETTYMORREL. Life of Man. Blossoms greenish white. Berries black. In moist, rich wood land. July.

It is aromatic. The berries give spirits an agreeable flavour. The bark of the root and berries are a good stomachic. It is said to have been much used by the Indians for medical purposes.

Aralia.

SARSAPARILLA. The roots extend a long way just under the surface of the ground. Stems naked; divided into three leaf-stalks. Leaves ovate; acuminate; serrated; three or five on a leaf-stalk, in a winged form. Blossoms in a globular umbel, rising from the *axillæ* of the leaf-stalks; white. Berries red. Common in loamy wood land. May.

The roots are aromatic and nutritious. They have been found beneficial in debilitated habits. It is said the Indians would subsist upon them, for a long time, in their war and hunting excursions. They make an ingredient in diet drinks.

STATICE? Linn. Gen. Plant. 348.

Statice caule nudo paniculato tereti, foliis lævibus. Syft. Nat.

MARSH ROSEMARY. Blossoms blue. Common in marshes. July.

The roots are powerfully astringent. A decoction of them is given, and used as a gargle, with success, in cankers and ulcerated fore throats.

DROSERA. Linn. Gen. Plant. 351.

Drosera scapis radicatis, foliis orbiculatis. Syft. Nat.

SUNDEW. Rosa Solis. Blossoms white. In mossy meadows. July—August.

The

The whole plant is sufficiently acrimonious to erode the skin. But Dr. *Withering* says, some ladies know how to mix the juice with milk, so as to make it an innocent and safe application to remove freckles and sunburn. The juice will destroy warts and corns. If the juice be put into a strainer, through which the warm milk from the cow is poured, and the milk set by for a day or two to become aced, it acquires a consistancy and tenacity—neither the whey nor the cream will separate. In this state it is used by the inhabitants in the north of *Sweden*, and called an extremely grateful food.

HEXANDRIA.

MONOGRNIA.

PONTEDERIA. Linn. Gen. Plant. 361.

Pontederia foliis cordatis, floribus spicatis. Syst. Nat.

PICKERELWEED. Blue Spike. Blossoms blue. Common on the borders of ponds and rivers. July.

LILIUM. Linn. Gen. Plant. 371.

Lilium foliis verticillatis, floribus reflexis, corollis revolutis. Syst. Nat.

MARTAGON. Curl-flowered Lily. Blossoms yellow, spotted with black. In *Taunton*, and very common in the state of *Rhode-Island*. July—August.

Lilium foliis verticillatis, floribus reflexis, corollis campanulatis. Syst. Nat.

YELLOW LILY. Blossoms yellow, with black spots. Common in meadows. July—August.

Lilium foliis verticillatis, flore erecto, corolla campanulata. Syst. Nat.

G g g

RED LILY.

RED LILY. Blossoms red, spotted with black. Common on borders of meadows. July.

UVULARIA. Linn. Gen. Plant. 373.

Uvularia foliis sessilibus. Syft. Nat.

BELLWORT. Sweet-smelling Solomon's Seal. Jacob's Ladder. Blossoms whitish. Common in wood land. May.

The young shoots may be eaten as asparagus. The roots are nutritious, and are used in diet-drinks.

ORNITHOGALUM. Linn. Gen. Plant. 377.

Ornithogalum scapo anguloso diphylo, pedunculis umbellatis simplicibus. Syft. Nat.

BETHLEMSTAR. Blossoms yellow. Common in grass land and amongst bushes. May.

The bulbous roots are nutritious and wholesome. It makes beautiful edgings for borders in gardens.

CONVALLARIA. Linn. Gen. Plant. 383.

Convallaria foliis amplexicaulibus plurimis, racemo terminali simplici? Syft. Nat.

SOLOMON'S SEAL. Leaves alternate, and are rather sessile than embracing the stem. Blossoms white. Berries red, or black. In rich wood land. May.

The young shoots may be eaten as asparagus. The roots are nutritious.

Convallaria foliis cordatis. Syft. Nat.

HAREWORT. Adder's Tongue. One radical leaf; two stem-leaves. Blossoms white. Berries red. Common amongst bushes in moist land. May.

In this plant we have an instance of the wrong application of an *English* name.—It is called *Adder's Tongue*, and mistaken for

for one of the ferns, which is known by that name in England.

ALETRIS. Linn. Gen. Plant 387.

Aletris floribus erectis. Syft. Nat.

UNICORN. Blossoms white. On high land in *Killingly*, in the state of *Connecticut*. July.

It is said to be useful in chronic rheumatisms.

ACORUS. Linn. Gen. Plant. 392.

SWEET FLAG. Spicewort. The leaves are thick ; narrow ; two-edged. Blossoms greenish. Common in watery places. July.

The roots and blossoms are aromatic and pungent. The dried roots are carminative. They are frequently grated into water, and given to children for pain in the stomach and bowels. The *Turks* candy the roots, and think they are a preservative against contagion.

BERBERIS. Linn. Gen. Plant. 399.

Berberis pedunculis racemosis. Syft. Nat.

BARBERRY. *Pipperidge Bush*. Blossoms yellow. Common. July.

The berries are used for pickles. Boiled with sugar, they form a most agreeable jelly. They are used likewise as a dry sweet-meat, and in sugar-plumbs. An infusion of the bark in white wine is purgative. The roots boiled in lye dye wool yellow. In *Poland*, they dye leather of the most beautiful yellow with the bark of the root. The inner bark of the stems dyes linen of a fine yellow, with the assistance of alum. It is said, that rye and wheat will be injured by this shrub, at the distance of three or four hundred yards ; but only when it is

in blossom, by means of the *farina fecundans* being blown upon the grain, which prevents the ears from filling.

TRIGYNIA. SIRTIA

RUMEX. Linn. Gen. Plant. 407.

Rumex floribus hermaphroditis: valvulis integris graniferis, foliis lanceolatis undulatis acutis. Syft. Nat.

CURLED DOCK. In fields. July.

Rumex floribus hermaphroditis: valvulis dentatis nudis, pedicellis plantis reflexis. Syft. Nat.

NARROW DOCK. About barns and in fields. July.

The roots of both these species are somewhat cathartic. The seeds are said to have been given with great advantage in the dysentery. The fresh roots bruised and made into an ointment, or decoction, cure the itch.

Rumex floribus hermaphroditis: valvulis integerrimis nudis foliis cordatis glabris acutis. Syft. Nat.

WATER DOCK. In muddy bottom brooks. Not common. July.

The Indians used this root with great success in cleansing foul ulcers. It is said they endeavoured to keep it a secret from the Europeans. Dr. Withering says, he saw an ill-conditioned ulcer in the mouth, which had destroyed the palate, cured by washing the mouth with a decoction of this root, and drinking a small quantity of the same decoction daily.

Not having opportunity to examine this plant since Dr. Withering's Botany came into my hands, the circumstances he mentions, respecting the *American* and *British* species, have not been particularly attended to. At the time it was examined, it appeared to correspond with the specific characters of *Linnaeus*, which are here given.

Rumex floribus dioicis, foliis oblongis sagittatis. Syft. Nat.

SORREL. Common in old fields. June.

MELANTHIUM. Linn. Gen. Plant. 410.

Melanthium petalis unguiculatis. Syft. Nat.

QUAFFIDILLA. Blossoms greenish yellow. In moist ground.
Not common. May.

MEDEOLA. Linn. Gen. Plant. 411.

Medeola foliis verticillatis, ramis inermibus. Syft. Nat.

INDIAN CUCUMBER. Blossoms greenish yellow. In rich
wood land. June.

The roots, which are of a conic form, are esculent and of
an agreeable taste. The Indians made them a part of their
food.

POLYGNIA.

ALISMA. Linn. Gen. Plant. 418.

Alisma foliis ovatis acutis, fructibus obtuse trigonis. Syft.
Nat.

WATER PLANTAIN. Blossoms white, with yellow antheræ.
Wet places. June.

HEPTANDRIA.

MONOGENIA.

TRIENTALIS. Linn. Gen. Plant. 419.

Trientalis foliis lanceolatis integerrimis. Syft. Nat.

WINTERGREEN. Blossoms white. Common in wood land.
May.

OCTANDRIA.

MONOGENIA.

RHEXIA. Linn. Gen. Plant. 423.

Rhexia foliis sessilibus serratis. Syft. Nat.
ROBINHOOD.

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ROBINHOOD. Leaves hairy. Blossoms pale red. In moist ground. July—August.

OENOTHERA. Linn. Gen. Plant. 424.

Oenothera foliis ovato—lanceolatis planis, caule lævi subvillosa. Syft. Nat.

SUNDROP. Blossoms in a kind of spike; yellow. They open about eleven o'clock, and, commonly, not more than one on the same day. In wet meadows. June.

Oenothera hirta, foliis supra glabris. Syft. Nat.

PRIMROSE. Leaves oblong; serrated. Blossoms in a large spike; terminating; yellow. Common in old fields. July.

This plant is very generally known by the name of *Scabious*, and seems to have been mistaken for the *Scabiosa arvensis* of *Linnaeus*. No species of *Scabious* has been found native in this part of the country.

EPILOBIUM. Linn. Gen. Plant. 426.

Epilobium foliis sparsis lineari—lanceolatis. Syft. Nat.

WILLOWHERB. Stamina erect. Blossoms in a long diffuse spike; purple. By fences in moist land. July.

Epilobium foliis oppositis lanceolatis integerrimis, petalis emarginatis, caule erecto. Syft. Nat.

MEADOW WILLOWHERB. Blossoms reddish. Moist land. July.

VACCINIUM. Linn. Gen. Plant. 434.

The species of this genus are generally known, and are too many to admit a particular description in this paper. The following are indigenous.

The

The *Black Whortleberry*. The *Bilberry* or *Blueberry*. These shrubs are low when they grow on high land, but tall in swamps. The *White Whortleberry*. The *Red Whortleberry*. The fruit of these species are agreeable to children, either eaten by themselves, or in milk, or in tarts and jellies. The *Cboke Whortleberry*. The fruit is unpalatable; but its great degree of astringency may, one day or other, recommend it to the attention of physicians. The *Craneberry*, or *Mossberry*. These berries make an agreeable tart. By drying them a little in the sun, and then putting them in a close vessel, or stopping them up in dry bottles, they may be kept good for many years.

TRIGYNIA.

POLYGONUM. Linn. Gen. Plant. 445.

Polygonum caule simplicissimo monostachyo, foliis ovatis in petiolum decurrentibus. Syft. Nat.

BISTORT. *Snakeweed*. Blossoms red. In wet meadows. August.

The root is said to be one of the strongest vegetable astringents.

Polygonum floribus hexandris semidigynis, foliis lanceolatis, stipulis submuticis. Syft. Nat.

ARSMART. *Water Pepper*. Blossoms white. Common both in dry and moist land. August.

It occasions severe smarting when rubbed on the flesh. The taste is acrid and burning. It dyes wool yellow. Dr. Withering says, it cures little apthous ulcers in the mouth.—That the ashes mixed with soft soap is a nostrum, in a few hands, for dissolving the stone in the bladder; but perhaps not preferable to other caustic preparations of the vegetable alkali.

Polygonum

Polygonum floribus hexandris, digynis, spicis ovato-oblongis, foliis lanceolatis, stipulis ciliatis. Syft. Nat.

HEARTSEASE. Spotted Arsmart. The leaves have a dark spot on their upper surface, in form of a crescent. Blossoms reddish white. Common about barns. August.

It will dye woollen cloth yellow, after the cloth has been dipped in a solution of alum.

Polygonum floribus octandris trigynis axillaribus, foliis lanceolatis, caule procumbente herbaceo. Syft. Nat.

KNOTGRASS. Blossoms reddish white. Common by the road sides. June—September.

Polygonum foliis sagittatis, caule aculeato. Syft. Nat.

SICKLEWEED. Bearded Arsmart. Blossoms white, tinged with red. In wet meadows. August.

Polygonum foliis cordatis, caule volubili, floribus planiusculis. Syft. Nat.

BLACK BINDWEED. Wild Bean. Blossoms greenish white. About barns and in corn fields. July—August.

ENNEANDRIA.

MONOGRNIA.

LAURUS. Linn. Gen. Plant. 452.

Laurus foliis enerviis ovatis utrinque acutis integris annuis. Syft. Nat.

FEVER BUSH. Blossoms yellowish. Berries red. Common in moist land. May.

This shrub is aromatic. A decoction of the small twigs makes an agreeable drink in slow fevers, and is much used by the country people. It is said the Indians esteemed it highly for its medicinal virtues.

Laurus

Laurus foliis trilobus integrisque. Syst. Nat.

SASSAFRAS. Blossoms greenish white. Common in loamy land. May.

It is generally a shrub, but sometimes grows into a large tree. The leaves fall early. The bark of the tree is aromatic, and has been substituted by people in the country for spice. It is said, that bedsteads made of this wood, will never be infested with bugs. It is said to be an excellent diuretic and diaphoretic, and therefore efficacious in obstructions of the viscera, cachexies, scorbutic complaints and in the venereal disease. An infusion of the bark of the roots makes a grateful drink. A very pungent, hot oil is extracted from it, which is said to possess most of the virtues of the wood. It has been exported in considerable quantities to Europe.

DECANDRIA.

MONOGYNIA.

PANTHEON. American Senna. The *Calix*, if properly any, a narrow husky border. *Corolla* three petals standing in a papilionaceous form. *Vexillum* very large; erect; slightly divided into three segments. *Alæ* narrow; obtuse; as long as the vexillum. *Carina* none. *Stamina* ten filaments; erect; separate; longer than the corolla. *Antheræ* orbicular. *Germen* ovate; hairy. *Stile* cylindrical; longer than the stamina. *Stigma* capitate; sending off several long hairs. *Capsule* ovate; five valves; five cells. Seeds many; small.

It is a small shrub. Leaves spear-shaped, and do not commonly appear until the shrub is in full bloom. Blossoms in tufts at the termination of the branches; bluish purple, clouded

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ed with dark red. It makes an elegant appearance amongst flowering shrubs in gardens. On the declivity of hills near swamps. May.

MONOTROPA. Linn. Gen. Plant. 477.

Monotropa caule unifloro, flore decandro. Syft. Nat.

BIRDSNEST. Blossoms yellow. About Great Offapy pond, in the state of New-Hampshire. July.

JUSSIÆA. Linn. Gen. Plant. 478.

WOOD PLANTAIN. Rattle-Snake Plantain. The germen within the corolla. The other characters agree with Linnaeus's description. The stems are erect, with only one or two small leaves; five petals in the flowers. Radical leaves large; ovate; slightly indented; spreading on the ground. Blossoms in open spikes; terminating; greenish white. In rich wood land. June.

It is said to cure the bite of a rattle-snake, by applying the chewed leaves to the wound, and swallowing a quantity of the juice. It commonly grows plentifully near their dens. Wherever these dangerous serpents haunt, nature seems to have provided an effectual antidote against their venom.

KALMIA. Linn. Gen. Plant. 482.

Kalmia foliis ovatis, corymbis terminalibus. Syft. Nat.

GREAT LAUREL. Wintergreen. Spoonhaunch. Blossoms white, tinged with red. In moist, rocky pastures. June—July.

The Indians are said to have made small dishes, spoons, and other utensils, out of the roots. They are sometimes employed by people in the country for similar purposes. They are large,

of

of a soft texture, and easily wrought when green; but when thoroughly dry, become very hard and smooth. Under cultivation it makes a most beautiful flowering shrub.

Kalmia foliis lanceolatis, corymbis lateralibus. Syst. Nat.

WINTERGREEN. Dwarf Laurel. Ivy. Lambkill. It is an ever-green. Blossoms variegated. Common in cold, wet land. June—July.

If the leaves are eaten by sheep, they prove fatal. Some have supposed, it is not owing to any poisonous, but an indigestive quality in the leaves, occasioned by the large quantity of resin they contain. Others say, that, in many instances, none of the leaves are found in the stomach, but evident marks of corrosive poison. It makes an elegant appearance, properly disposed amongst other flowering shrubs, in a border. But its being so common, and the disadvantage it usually appears under in a wild state, have prevented its being introduced into gardens.

ANDROMEDA. Linn. Gen. Plant. 485.

Andromeda racemis secundis nudis, corollis rotundo-ovatis. Syst. Nat.

WHITE PEPPERBUSH. Blossoms white. Common in swamps. June.

It is generally called *Oser*, which is the *English* name of the *Salix viminalis* of *Linnaeus*, one of the species of the *Willow*. It is used for fish-flakes, and, as the wood is very hard and durable, is one of the best shrubs employed for that purpose.

Andromeda.

GARDOBE. Bog Ever-green. Fruit-stalks single; in the axillæ of the leaves. Corolla ovate. Leaves lanceolate; al-

H h h 2

ternate.

ternate. Blossoms pendent; white. Common in fens and quagmires. April—May.

ARBUTUS. Linn. Gen. Plant. 488.

Arbutus caule erecto, foliis glabris integerrimis, baccis polyspermis. Syft. Nat.

FOXBERRY. Checkerberry. Blossoms white. Berries red. Common in pine and shrub oak land. It blooms in July and August, but the fruit is not ripe until the next spring.

It is in a very small degree aromatic. The leaves are much celebrated by the common people as a diuretic and sweetner of the blood, but are of very little efficacy. It makes an ingredient in their diet-drinks. The berries are rather of an agreeable taste, and are sometimes eaten by children in milk.

CLETHRA. Linn. Gen. Plant. 489.

SWEET PEPPERBUSH. A shrub. Leaves inversely ovate; serrated. Blossoms in long spikes; terminating; white. Common in moist land and swamps. July—August.

PYROLA. Linn. Gen. Plant. 490.

Pyrola staminibus adscendentibus, pistillo declinato. Syft. Nat.

CONSUMPTION-ROOT. Blossoms white. In wood land. July.

Pyrola floribus racemosis dispersis, staminibus pistillisque rectis. Syft. Nat.

RHEUMATISM-WEED. Blossoms pale red. In wood land. It abounds near White-Mountains.

It is said to have been considered by the Indians as an effectual remedy in rheumatisms.

FALSEVINE.

FALSEVINE. The *calix* is a permanent perianthium of one leaf; bell-shaped. Limb divided into ten small, unequal, erect segments. *Corolla* five narrow, patent petals; inserted into the mouth of the cup. *Stamina* ten subulated filaments; longer than the corolla. *Antheræ* oblong. *Germen* above; globular. *Stile* cylindrical; shorter than the cup. *Stigma* capitate and jagged. Capsule globular; three cells; three valves. Seeds many; small; ovate.

The stem is angular; reclining. If the end touches the ground it takes root. Leaves spear-shaped; entire. Blossoms on short flower-stalks rising from the *axillæ* of the leaves; deep purple. In wet meadows, and on the borders of ponds and rivers. July.

This plant, if it be eaten in large quantities, will occasion abortion in all kinds of herbivorous animals. It is frequently mowed with meadow-grass, and seems to be grateful food in the winter to all sorts of cattle. But in some instance it has deprived farmers of almost all the increase of their stock in the spring. Those who are acquainted with its baneful effects, are careful to separate it from their hay, when they rake it.

DIGYNIA.

SAXIFRAGA. Linn. Gen. Plant. 494.

Saxifraga foliis lanceolatis denticulatis, caule nudo paniculato, floribus subcapitatis. Syst. Nat.

GOLDEN SAXIFRAGE. Blossoms redish.

TRIGYNIA.

CUCUBALUS. Linn. Gen. Plant. 502.

Cucubalus calycibus subglobosis glabris reticulato-venosis, capsulis trilocularibus, corollis subnudis. Syst. Nat.

CAMPION.

CAMPION. Bladder Beben. Bellweed. Blossoms white.
On borders of fields in Lynn. July.

STELLARIA. Linn. Gen. Plant. 504.
Stellaria foliis linearibus integerrimis, floribus paniculatis.
Syft. Nat.

STITCHWORT. Blossoms in panicles; white. Amongst
bushes. May.

ARENARIA. Linn. Gen. Plant. 505.
Arenaria foliis filiformibus, stipulis membranaceis vaginantibus.
Syft. Nat.

SANDWORT. Blossoms redish white. On the sea shore.
August.

Arenaria foliis ovatis nervosis sessilibus acutis. Syft. Nat.
SPURRY. Blossoms white. In wood land. July.

PENTAGYNIA.

OXALIS. Linn. Gen. Plant. 515.
*Oxalis scapo unifloro, foliis ternatis, radice squamosa articula-
ta.* Syft. Nat.

WOOD SORREL. Cuckow-Bread. Sour Trefoil. In rainy
weather the leaves stand upright, but in dry weather they hang
down. Blossoms yellow. In shady places. May—August.

Dr. Withering says, the expressed juice depurated properly
evaporated, and set in a cool place, affords a chrystalline acid
salt in considerable quantity, which may be used wherever ve-
getable acids are wanted. The London College directs a con-
serve to be made with the leaves beaten with thrice their weight
of fine sugar. The juice is gratefully acid. An infusion of
the leaves is an agreeable liquor in ardent fevers.

SPERGULA.

SPERGULA. Linn. Gen. Plant. 319.

Spergula foliis verticillatis, floribus pentandris. Syst. Nat.

PINER. Spurry. Blossoms white. In cultivated ground, especially among flax. August.

DECAGYNIA.

PHYTOLACCA. Linn. Gen. Plant. 521.

Phytolacca floribus decandris. Syst. Nat.

GARGET. Cunicum. Skoke. American Nightshade. Blossoms white, tinged with red. Berries black. Common by road sides. July.

The juice of the berries gives a fine purple tincture to paper, but it soon fades. The berries are employed in dyes by the country people, but the colours are not lasting. They would make a most beautiful purple dye, if some method could be found for fixing the colour. The roots are emetic and cathartic. An ounce of the dried root, infused in a pint of wine, and given to the quantity of two spoonfuls, frequently operates very kindly as an emetic. In some cases it is preferable to most other emetics, as it hardly alters the taste of the wine. The roots are applied to the hands and feet in ardent fevers. Farriers give a decoction of them to drench cattle, and apply them, in form of poultice, for discussing tumors. The young shoots boiled, are hardly to be distinguished from spinach, and are nutritious and wholesome. Poultry are fond of the berries; but, if eaten in large quantities, will give their flesh a disagreeable flavour.

DODECANDRIA.

MONOGYNIA.

PORTULACA. Linn. Gen. Plant. 531.

Portulaca foliis cuneiformibus floribus sessilibus. Syst. Nat.

PURSLANE. The number of the stamina are inconstant. Blossoms yellow. In corn-fields. July. It

It is eaten as a pot-herb, and esteemed by some as little inferior to asparagus.

LYTHRUM. Linn. Gen. Plant. 532.

Lythrum foliis alternis linearibus, floribus hexandris. Syst. Nat.

WILD HTSSOP. Grasspoly. Blossoms purple. In wet land. June—July.

DIGNIA.

AGRIMONIA. Linn. Gen. Plant. 534.

Agrimonia foliis caulinis pinnatis : foliolis undique serratis : omnibus minutes interstinctis, fructibus hispida. Syst. Nat.

AGRIMONY. The number of stamina from five to twelve. Blossoms on long terminating spikes ; yellow. By fences. July.

It is said the Indians used an infusion of the roots in inflammatory fevers, with great success. Dr. Hill says, an infusion of six ounces of the crown of the root in a quart of boiling water, sweetened with honey, and half a pint of it drank three times a day, is an effectual cure for the jaundice. He advises to begin with a vomit, afterwards to keep the bowels soluble, and to continue the medicine as long as any symptoms of the disease remains.

ICOSANDRIA.

MONOGYNIA.

PRUNUS. Linn. Gen. Plant. 546.

Specific descriptions under this genus, as well as that of the *Vaccinium*, are, for the same reasons, omitted. The trees and shrubs found growing naturally, are known by the following names.

The

The *Beach*, or *Sea-Side Plumb*. There are several varieties of this species growing plentifully on *Plumb-Island*. The fruit of some of them, when fully ripe, is well-tasted. They are easily propagated in gardens, by planting the stones in a mixture of beach sand and loam, and will produce fruit in two or three years.

The *Black Cherry Tree*. It is common, grows large, and the wood, which is smooth and hard, is used by cabinet-makers in many kinds of work. They have the art of giving it a stain which approaches the colour of mahogany. The fruit is rather indifferent in its natural state, but might probably be greatly improved by cultivation. It is infused in rum and brandy for the sake of giving them an agreeable flavour. An infusion or tincture of the inner bark is given with success in the jaundice.

The *Small Black Cherry*. The tree is small and shrubby, and the fruit not so well flavoured as the large black cherry.

The *Black Choke Cherry*. A low shrub. The *Large Red Cherry*. A small tree. The *Dwarf Red Cherry*, A very low shrub. The *Red Choke Cherry*. A shrub. The *Small Pale Red Cherry*. A small tree, and the fruit hard and ill-tasted.

The last-mentioned cherry tree abounds, where land has been cleared, in the new plantations near *White-Mountains*, but is rarely, if at all, found in the forests. Some have asserted, that this species of cherry tree is not found in that part of the country, except in places where the native growth has been destroyed. In land, where there is no kind of cherry trees after the old growth, which consists chiefly of spruce, pine, beach and birch, (exceedingly tall and large) has been fell and burnt on the ground, there springs up, the next summer, an immense

number of these cherry trees. By what means are they produced? The doctrine of equivocal, or spontaneous generation, has long been exploded. Nature has not formed the seeds for being wafted by the wind. Can it be supposed such vast numbers were scattered by birds? Or, upon this supposition, is there not difficulty in conceiving, that neither the long period of time which most of them must be supposed to have laid in the ground, nor the intense heat, occasioned by burning such prodigious piles of wood, should destroy their vegetive quality?

DIGYNIA

CRATÆGUS. Linn. Gen. Plant. 547.

Cratægus foliis cordatis repando-angulatis serratis glabris. Syft. Nat.

HAWTHORN. Blossoms white. Fruit red. In dry land. May. It is said that an ardent spirit may be distilled from the fruit.

Cratægus foliis lanceolato-ovatis serratis glabris, ramis spinosis. Syft. Nat.

THORNBUSH. Blossoms white. Fruit red. Common in hedges. May.

PENTAGYNIA

PYRUS. Linn. Gen. Plant. 550.

Pyrus foliis serratis, floribus corymbosis. Syft. Nat.

BASTARD PEAR, *Juniper*. A shrub which blooms very early in the spring, commonly before other trees are leaved out. Blossoms white. The fruit is redish, small, nearly round, and well tasted. It ripens in June; but birds are so fond of it that they rarely suffer it to remain until it is ripe. It is eaten by children in milk. Common in moist land.

SPIRÆA. Linn. Gen. Plant. 554.

Spiræa foliis lanceolatis obtusis serratis nudis, floribus duplicato-racemosis. Syft. Nat.

MEADOW

MEADOW SWEET. Blossoms white, tinged with red. In moist pastures. August.

Spiræa foliis lanceolatis inæqualiter serratis subtus tomentosis, floribus duplicato-racemosis. Syst. Nat.

QUEEN OF THE MEADOWS. Blossoms red or purple. In moist pastures. July—August.

POLOGYNIA.

ROSA. Linn. Gen. Plant. 556.

Rosa germinibus globosis hispidis, pedunculis subhispidis, caule aculeis stipularibus, petiolis aculeatis. Syst. Nat.

WILD ROSE. Dog Rose. Blossoms red. Berry pale red. Common in moist land. June.

The blossoms gathered before they expand, and dried, are astringent; but when full blown, are purgative. This species is generally preferred for conserves. A perfumed water may be distilled from the blossoms. The pulp of the berries, beat up with sugar, makes the conserve of hepps of the London dispensatory. The dried leaves of every species of rose have been recommended as a substitute for India tea, giving out a fine colour, a sub-astringent taste, and a grateful smell.

RUBUS. Linn. Gen. Plant. 577.

Rubus foliis quinato-pinnatis ternatisque, caule aculeato, petiolis canaliculatis. Syst. Nat.

RASPBERRY. Blossoms white. Berry pale red. Common by stone walls. June.

The fruit is sub-acid, cooling and extremely grateful. If it be made into sweet-meat, with sugar, or fermented with wine, the flavour is improved. It is eaten in milk, and with cream and sugar. Dr. Withering says, it dissolves the tartarous con-

cretions of the teeth ; but for this purpose it is inferior to the strawberry.

Rubus foliis ternis subtus tomentosis, caule aculeato, petiolis teretibus. Syft. Nat.

BRAMBLE. Upright Brier. Blossoms white. Berry dark brown. In hedges. June.

Rubus foliis ternatis subnudis : lateralibus bilobis, caule aculeato tereti. Syft. Nat.

SMALL BRAMBLE. Blackberry Brier. Dewberry. Blossoms white. Berry black. Common in old fields. June.

Rubus foliis quinato-digitatis ternatisque, caule petiolisque aculeatis. Syft. Nat.

SOWTEAT. Bumblekites. Blossoms white. Berries black. In hedges, and by fences. May—June.

The fruit is pleasant to eat, and communicates a fine flavour to red wine. It is frequently infused in brandy and rum. The green twigs are said to be of great use in dying woollen, silk and mohair black.

Rubus foliis digitatis denis quinis ternatisque, caule inermi. Syft. Nat.

SUPERB RASPBERRY. Blossoms large ; in panicles ; petals purple ; antheræ yellow. Berry redish yellow. In high land on the declivity of hills. It grows plentifully in the new-plantations at the northward. June—September.

The fruit is much larger and more delicious than the common raspberry. It is easily cultivated in gardens ; and the large size of the leaves and blossoms give it an elegant appearance. Ripe fruit and blossoms are commonly found on the same panicles.

Rubus

Rubus foliis simplicibus cordatis lobatis, caule aculeato decumbente. Syft. Nat.

BLACKBERRY. Blossoms white: Berry black. Common in old fields. May.

The fruit is well tasted. Children are fond of them in milk. They are infused in rum and brandy, and give them a flavour little inferior to that of black cherries.

FRAGARIA. Linn. Gen. Plant. 558.

Fragaria flagellis reptans. Syft. Nat.

STRAWBERRY. Blossoms white. Berry red. In fields and pastures. May.

The fruit in its uncultivated state, if the soil be rich, is large and well tasted, but may be greatly improved by culture. The white fruited, double flowering, and other varieties, are produced by cultivation. It is sub-acid, cooling, and may be eaten in large quantities without offending the stomach. Dr. *Withering* says, they promote perspiration, impart a violet smell to the urine, and dissolve the tartarous incrustations upon the teeth. People afflicted with the stone or gout have found great relief by using them very freely. *Hoffman* says, he has known consumptive people cured by them. They are universally esteemed a most delicious fruit, either eaten alone, or with sugar or milk.

POTENTILLA. Linn. Gen. Plant. 559.

Potentilla foliis pinnatis serratis, caule repente. Syft. Nat.

MARSH TANSY. *Silverweed.* Blossoms yellow. Borders of marshes. June.

Potentilla foliis quinatis, caule repente, pedunculis unifloris. Syft. Nat.

CINQUEFOIL.

CINQUEFOIL. *Fivesinger*. Blossoms yellow. In old fields. June.

It is mildly astringent and antiseptic. A decoction of it is used as a gargle for loose teeth and spongy gums.

GEUM. Linn. Gen. Plant. 561.

Geum floribus erectis, fructu globofo: aristis uncinatis nudis, foliis ternatis. Syst. Nat.

BENNET. *Common Avens. Herb-Bennet.* Blossoms white or yellow. By fences and borders of fields. July.

Dr. *Withering* says, the roots gathered in the spring, before the stem grows up, and put into ale, give it a pleasant flavour, and prevent its growing sour. Infused in wine it is a good stomachic. When it grows in warm dry situations, its taste is mildly austere and aromatic.

Geum floribus nutantibus, fructu oblongo: aristis plumosis. Syst. Nat.

WATER AVENS. *Throatroot. Cureall.* Blossoms purplish. In boggy meadows. May.

The root is powerfully astringent. A decoction of it has been used, with good success, as a gargle, and a drink, in inflamed and ulcerated sore throats, and cankers. It is said, that the powdered root will cure tertian agues, and that it is much used by the *Canadians* for that purpose.

POLYANDRIA.

MONOGYNIA.

ACTÆA. Linn. Gen. Plant. 568.

Actæa racemo ovato, fructibus baccatis. Syst. Nat.

CHRISTOPHER. *Baneberries.* Blossoms white. Berry red. In wood land and shady places. May.

The

The berries are exceedingly poisonous. Dr. Withering says, the plant is powerfully repellant ; and that the root is useful in some nervous cases, but it must be administered with caution. It is said, that toads, allured by the fetid smell of this plant, resort to it.

SANGUINARIA. Linn. Gen. Plant.

BLOODROOT. Puccoon. Leaves roundish ; deeply indented. Stems naked ; supporting single flowers. Blossoms white. In rich wood land. April.

When the fresh root is broken, a juice issues, in large drops, resembling blood. The Indians used it for painting themselves, and highly esteemed it for its medical virtues. It is emetic and cathartic, but must be given with caution. An infusion of the root in rum or brandy makes a good bitter. If it be planted in rich shady borders, it flourishes well in gardens ; and the large leaves and blossoms make an agreeable appearance soon after the frost is out of the ground.

CHELIDONIUM. Linn. Gen. Plant. 572.

Chelidonium pedunculis umbellatis. Syst. Nat.

GELANDINE. Blossoms yellow. Common by fences and amongst rubbish. June—August.

This plant is very acrimonious. The juice destroys warts, and cures ringworms. Diluted with milk, it is said to consume white opaque spots upon the eyes.

SARRACENIA. Linn. Gen. Plant. 578.

Sarracenia foliis gibbis. Syst. Nat.

SARRACENE. Side-Saddle Flower. Hallow-leaved Plant.

The leaves are tubular, somewhat resembling the horn of an ox inverted. The aperture at the top is horizontal and circular, with

with a broad patent, foliaceous appendage, extending two-thirds of the way round it. A similar appendage runs down the concave side to the root. The cavities of the leaves are large, and generally contain a quantity of water. They seem to be designed by nature for reservoirs, from which the plants may be constantly supplied with moisture. The stems are erect and naked. Blossoms single, terminating and reclining; petals red; the stigma, which covers the disk, redish green. In moist land, especially in fens and quagmires. May—June.

NYMPHÆA. Linn. Gen. Plant. 579.

Nymphaea calyce magno pentaphyllo. Syft. Nat.

WATER YELLOW LILY. Toad Lily. Blossoms yellow. In ponds and rivers. June.

Nymphaea foliis cordatis integerrimis, calyce quadrifido. Syft. Nat.

POND LILY. Water Lily. Blossoms white. In ponds and rivers. July.

The flowers open about seven in the morning, and close about four in the afternoon. A conserve is made of the leaves of the blossoms. The roots of both species are much used, in form of poultices, for producing suppuration in boils and painful tumors, and are very efficacious. The root of the water yellow lily is generally preferred. Dr. Withering says, the roots of the pond lily are used in Ireland, and in the island of Jura, to dye a dark brown.

BIXA. Linn. Gen. Plant. 581.

BASS WOOD. White Wood. Suggumug. The stigma is quadrifid. Blossoms white. In woods. Not common. July.

This

This tree is of a middling size, and the wood very white and soft. When it is perfectly dry it swims on the water like cork. It is used by turners for making bowls, trenchers and dishes.

CISTUS. Linn. Gen. Plant. 598.

Cistus herbaceus exstipulatus, foliis omnibus alternis lanceolatis, caule adscendente. Syst. Nat.

AMERICAN CISTUS. Little Sunflower. Blossoms yellow, and the disk commonly turned towards the sun from morning until night. In dry pastures. June.

PENTAGYNIA.

AQUILEGIA. Linn. Gen. Plant. 605.

Aquilegia nectarius rectis, staminibus corolla longioribus. Syst. Nat.

COLUMBINE. Honey Horns. Blossoms red. Amongst rocks in dry land. May.

Cultivation renders it equal in beauty to any of the exotic columbines. It makes an elegant appearance among them, and adds to the variety in flower-borders.

NIGELLA ? Linn. Gen. Plant. 606.

GOLDENTHREAD. Mouth Root. The number of petals from five to seven; commonly six. Nectaria six cups; supported on filament nearly as long as the stamina. Germina from three to seven; commonly six.

The roots thread-shaped; running; bright yellow. Leaves grow by threes; circular; scolloped. Stems erect; naked. Blossoms solitary; terminating; white. Common in swamps. May.

The roots are astringent, and of a bitterish taste. Chewed in the mouth they cure apthas and cankerous sores. It is frequently an ingredient in gargles for sore throats.

K k k

POLYGYNIA.

POLYGYNA.

ANEMONE. Linn. Gen. Plant. 614.

Anemone foliis trilobis integerrimis. Syft. Nat.

LIVERWORT. Blossoms white, tinged with red. In woods and shady places. April.

Anemone pedunculo nudo, seminibus subrotundis hirsutis. Syft. Nat.

WHITE ANEMONE. Blossoms white. Amongst bushes, and in shady places. May.

Anemone seminibus acutis, foliolis incis, caule unifloro. Syft. Nat.

WOOD ANEMONE. Blossoms white, tinged with purple. In woods and newly-cleared land. May.

CLEMATIS. Linn. Gen. Plant. 616.

Clematis foliis ternatis, foliolis cordatis serrato-angulatis, scandentibus. Syft. Nat.

TRAVELLER'S JOY. Virgin's Bower. Blossoms white. Banks of brooks and river's. July.

RANUNCULUS. Linn. Gen. Plant. 619.

Ranunculus foliis radicalibus reniformibus crenatis sublobatis, caulinis tripartitis lanceolatis integerrimis, caule multifloro. Syft. Nat.

PILEWORT. Burwort. Blossoms yellow. By fences. September.

Ranunculus foliis radicalibus subrotundo-cordatis crenatis; caulinus digitatis dentatis, caule multifloro. Syft. Nat.

CROWFOOT. Buttercup. Goldilocks. Blossoms yellow. Common in moist pastures and fields. June—July.

The whole plant is acrid. The blossoms cure warts and corns.

CALTHA.

CALTHA. Linn. Gen. Plant. 623.

MEADOW-BOUTS. Cowslips. Marsh Marigold. Stems branched. Leaves kidney-shaped. Blossoms yellow. In brooks and watery places. April—May.

Many people esteem it a good pot-herb. Dr. *Withering* says, the flowers gathered, and preserved in salted vinegar, are a good substitute for capers. The juice of the flowers boiled, with the addition of alum, stains paper yellow. It has been supposed, that the remarkable yellowness of butter in the spring, is caused by this plant: but *Boerhaave* says, if cows eat it, it will occasion such inflammation, that they generally die.

DIDYNAMIA.

GYMNOSPERMIA.

TEUCRIUM. Linn. Gen. Plant. 625.

Teucrium foliis ovatis inæqualiter serratis, racemis terminalibus. Syft. Nat.

GERMANDER. Wood Sage. Blossoms white, tinged with red. Near Dummer Academy. Not common. July.

NEPETA. Linn. Gen. Plant. 629.

Nepeta floribus spicatis: verticillis subpedicellatis, foliis petiolatis cordatis dentato-serratis. Syft. Nat.

CATMINT. Catnip. Blossoms pale purple, or blue. About barns and fields. July.

An infusion of the plant, especially of the blossoms, is grateful to the stomach, and a mild carminative, but of no great efficacy. Dr. *Withering* says, an infusion of it is deemed a specific in chlorotic cases. It is much used by the country people here in the same cases. Cats are remarkably fond of this plant. Mr. *Miller* says, they eat it until it produces a kind of drunkenness, and then tear it to pieces with their claws.

BETONICA. Linn. Gen. Plant. 631.

Betonica spica interrupta, corollaram lacinia labii intermedia emarginata? Syft. Nat.

HEAD BETONY. The middle segment of the lower lip of the blossom is toothed. Blossoms purple. Woods and fields. July — August.

Dr. Withering says, the fresh leaves intoxicate, and the dry leaves excite sneezing; — that it is smoked as tobacco; and that the roots provoke vomiting.

MENTHA. Linn. Gen. Plant. 633.

Mentha floribus spicatis, foliis oblongis serratis.

HORSE MINT. Blossoms blue. By brooks, and in wet meadows. July.

Mentha spicis solitaris interruptis, foliis lanceolatis serratis sessilibus. Syft. Nat.

SPEAR MINT. Blossoms purplish red. In moist ground. August.

It has a more agreeable flavour than the Horse Mint, and is preferred for culinary and medical purposes. The juice of the leaves, boiled up with sugar, is formed into tablets. The leaves make an agreeable conserve. The distilled waters, both simple and spiritous, are generally esteemed pleasant. The essential oil and distilled waters are considered as carminative. They are given with success for removing sickness at the stomach.

Mentha floribus capitatis, foliis ovatis serratis petiolatis, staminibus corolla longioribus. Syft. Nat.

WATER MINT. Blossoms pale red. By brooks and rivers. August.

Mentha

Mentha floribus verticillatis, foliis ovatis obtusis suberenatis caulebus subteretibus repentibus. Syft. Nat.

PENNYROYAL. Stamina pale purple. In pastures and fields. July—September.

The expressed juice, with sugar, is given in the hooping cough. An infusion of the plant and the distilled water are antispasmodic, and are prescribed in hysterical cases.

GLECOMA. Linn. Gen. Plant. 634.

Glecoma foliis reniformibus crenatis. Syft. Nat.

GROUND IVY. Gill-go-over-the-Ground. Robin-run-away.

A decoction of the leaves is esteemed by the common people a remedy for the jaundice. Dr. Withering says, the leaves are thrown into the vat with ale, to clarify it, and give it a flavour: and that ale thus prepared, is often drank as an antiscorbutic. The expressed juice mixed with wine, and applied morning and evening, it is said, will destroy white specks upon horses eyes. The plant is also said to be hurtful to horses, if they eat it in large quantities.

GALEOPSIS. Linn. Gen. Plant. 637.

Galeopsis internodiis caulinis superne incrassatis, verticillis summis subcontiguis. Syft. Nat.

ALLHEAL. Hemp-leaved Dead-Nettle. Blossoms purple. By the road side. Gloucester. August.

STACHYS. Linn. Gen. Plant. 638.

Stachys verticillis sexfloris, foliis cordatis petiolatis. Syft. Nat.

CLOWNHEAL. Hedge Nettle. Blossoms purple, spotted with white. By fences and amongst bushes. July—August.

It has a foetid smell, and roads are thought to be fond of living under its shade. It will dye yellow.

MARRUBIUM.

MARRUBIUM. Linn. Gen. Plant. 640.

Marrubium dentibus calycinis setaceis uncinatis. Syft. Nat.

HOREHOUND. Blossoms white. By road sides, and among rubbish. July.

Dr. Withering observes, that it was a favourite medicine with the ancients in obstructions of the viscera.—In large doses it loosens the belly. He says, that it is the principal ingredient in the Negro *Cæsar's* remedy for vegetable poisons.—That a young man, who had occasion to take mercurial medicine, was thrown into a salivation, which continued for more than a year. Every method that was tried to remove it, rather increased the complaint. At length *Linnaeus* prescribed an infusion of this plant, and the patient got well in a short time.

LEONURUS. Linn. Gen. Plant. 641.

Leonurus foliis caulinis lanceolatis trilobis. Syft. Nat.

MOTHERWORT. Blossoms purplish. Among rubbish. July—August.

Leonurus foliis ovatis lanceolatisque serratis, calycibus sessilibus spinosis. Syft. Nat.

MARRUBY. Lion's Tail. Blossoms redish. By fences in moist land. Not common. July.

ORIGANUM. Linn. Gen. Plant. 645.

Origanum spicis subrotundis paniculatis conglomeratis, bracteis calyce longioribus ovatis. Syft. Nat.

WILD MARYJAM. Blossoms purple. Amongst brambles by fences. July.

It is warm and aromatic. Dr. Withering says, the essential oil is so acrid that it may be considered as a caustic, and is much used with that intention by farriers. A little cotton wool moistened

ened with it, and put into the hollow of an aching tooth, frequently relieves the pain. The dried leaves make an exceedingly grateful tea. The tops of the plant dye purple.

DRACOCEPHALUM. Linn. Gen. Plant. 648.

Dracocephalum floribus spicatis, foliis lanceolatis serratis.
Syst. Nat.

DRAGON'S HEAD. The middle segment of the lower lip the largest; intire. Blossoms variegated with red and white. By stone walls in Dedham. July.

TRICHOSTEMA? Linn. Gen. Plant. 652.

Trichostema staminibus longissimis exertis. Syst. Nat.

WILD LAVENDER. Great Pennyroyal. The upper lip divided into two erect segments; compressed. The lateral segments of the lower lip erect; nearly similar to the segments of the upper lip; middle segment larger; club-shaped; convex; reflected. Stigma bifid; reflected. Blossoms solitary; terminating; purple. In old fields. August—September.

SCUTELLARIA. Linn. Gen. Plant. 653.

Scutellaria foliis sessilibus ovatis: inferioribus obsolete serratis; superioribus integerrimis. Syst. Nat.

HOODWORT. Blossoms blue. By fences in Sandwich. Aug.

Scutellaria foliis cordato-oblongis acuminatis serratis, spicis subnudis. Syst. Nat.

TALL HOODWORT. Blossoms pale blue. In open wood land in Weymouth. August.

ANGIOSPERMIA.

EUPHRASIA. Linn. Gen. Plant. 659.

Euphrasia foliis linearibus serratis: superioribus integerrimis.
Syst. Nat.

EYEBRIGHT.

STEBRIGHT. *Mouthwort.* Blossoms blue. Amongst low bushes. July.

It has been in repute for recovering impaired eye-sight.

MELAMPYRUM. Linn. Gen. Plant.

Melampyrum corollis hiantibus. Syft. Nat.

COW-WHEAT. Blossoms yellowish white. In woods. June.

CHELONE. Linn. Gen. Plant. 666.

Chelone foliis lanceolatis serratis: summis oppositis. Syft. Nat.

CHELONE. *Fish-head. Snake-head.* Blossoms in spikes; white. Common by fences and amongst bushes in moist land. August.

ANTIRRHINUM. Linn. Gen. Plant. 668.

Antirrhinum foliis lanceolatis obtusis alternis; caule ramosissimo diffuso. Syft. Nat.

-TOAD-FLAX. Blossoms purple. In fields and road sides. June—August.

Antirrhinum foliis linearibus alternis, corollis hiantibus: labio inferiore explanato. Syft. Nat.

SNAP-DRAGON. *Fhuellin.* Blossoms yellow, with a mixture of scarlet. Common by road sides in Lynn and Cambridge. June—July.

The seed of a species of the Antirrhinum, nearly resembling this plant, and not at all superior in beauty, is imported by our seed-sellers, and is common in curious flower-gardens.

SCROPHULARIA. Linn. Gen. Plant. 674.

Scrophularia foliis cordatis serratis acutis basi rotundatis, caule obtusangulo. Syft. Nat.

FIGWORT. Blossoms purplish, with a small segment, resembling a lip, in their mouths. By fences in wet land. Aug.

The

The plant has a rank smell and bitter taste. It is said, that swine that have the scab are cured by washing them with a decoction of the leaves.

DIGITATIS. Linn. Gen. Plant. 676.

Digitatis calycinis foliis ovatis acutis, corollis obtusis: labio superiore integro. Syst. Nat.

FOX-GLOVE. Hornwort. Blossoms red. In moist land. Aug.

This is another plant which has been mistaken for *Paul's Betony*, a species of the *Veronica*.

BIGNONIA. Linn. Gen. Plant. 677.

TRUMPET-FLOWER. Yellow Jasmine. Stems round; erect. Leaves lanceolate; opposite; irregularly serrated. Blossoms solitary; on short flower-stalks rising from the *axillæ* of the leaves; yellow. On the borders of fields, and in open woods. July.

This plant has also been called *Paul's Betony*.

WOOD BETONY. The *calix* a perianthium of one leaf; tubular. Border entire; sloped. *Corolla* one petal; gaping. Tube twice the length of the calix. Upper lip helmet-shaped, with two awns. Lower lip reflected; three concave segments, the middle one smaller. *Stamina* four filiform filaments, (two a little shorter than the other two) concealed by the upper lip. *Antheræ* cloven. *Germe* ovate; compressed. *Stile* filiform; longer than the *stamina*. *Stigma* obtuse. *Capsule* ovate; acuminate; compressed; with two cells and two valves. Seeds ovate; several.

Stems erect. Leaves lanceolate; deeply divided in a pinnated form; the divisions serrated. Blossoms in spikes; yellow. Common in rich wood land. June.

MIMULUS. Linn. Gen. Plant. 701.

MAIDENWORT. Stems angular ; branched. Leaves lanceolate ; slightly serrated ; opposite ; half embracing the stalk. Blossoms solitary ; on long flower-stalks rising from the axillæ of the leaves ; blue. By fences in moist land. August.

TETRADYNAMIA.

SILICULOSÆ.

MYAGRUM. Linn. Gen. Plant. 713.

Myagrum filiculis ovatis pedunculatis polyspermis. Syft. Nat.

CAMLIN. Blossoms yellow. In fields amongst flax. June.

THLASPI. Linn. Gen. Plant. 719.

Thlaspi filiculis obcordatis, foliis radicalibus pinnatifidis. Syft. Nat.

MITHRIDATE. Shepherd's Purse. Shepherd's Pouch. Blossoms white. In corn fields, and about barns. April—June.

COCHLEARIA. Linn. Gen. Plant. 720.

Cochlearia foliis radicalibus subrotundis, caulinis oblongis, sub-sinuatis. Syft. Nat.

SCURVY-GRASS. Blossoms white. On high land. Not common in a wild state, but is frequently cultivated in gardens. May—June.

It is acrimonious ; and the acrimony is said to reside in a very subtile essential oil. It is frequently eaten by country people as a sallad. Writers on sea-voyages give high encomiums on the Scurvygrass for its antiscorbutic virtues. Dr. Withering says, it is a powerful remedy in the pituitous asthma, and in what Sydenham calls the scorbutic rheumatism. A distilled water and a conserve is prepared from the leaves. The juice is prescribed along with that of oranges, by the name of antiscorbutic juices.

Cochlearia

Cochlearia foliis radicalibus lanceolatis integerrimis, caulinis subfinuatis. Syft. Nat.

SEA SCURVYGRASS. The leaves are fleshy. Blossoms white. On the sea shore and in marshes. May—June.

This is more acrimonious than the former species. It has a pretty full taste of sea salt, as well as the volatile alkali.

Cochlearia foliis lanceolatis amplexicaulibus dentatis. Syft. Nat.

HORSE-RADISH. Blossoms white. In rich soil in moist land. Not common in an uncultivated state. June—July.

It is so rarely found where it has not been cultivated, that it may possibly be doubted whether it be indigenous. The scraped roots are much used at tables as a condiment, and for many culinary purposes. It has been found a powerful stimulant in paralytic cases, and is useful as a diuretic in dropfies. A distilled water is prepared from it. A strong infusion is emetic.

SILIQUOSA.

CARDAMINE. Linn. Gen. Plant. 727.

Cardamine foliis pinnatis extipulatis, foliolis lanceolatis obtusis, floribus corollatis. Syft. Nat.

LADYSMOCK. Blossoms white. Near small brooks. Not common. May—June.

Cardamine foliis pinnatis : foliolis lanceolatis basi unidentatis. Syft. Nat.

IMPATIENT. Impatient Ladysmock. Blossoms yellowish white. By springs in mountainous land. Very rare. May.

SISYMBRIUM. Linn. Gen. Plant. 728.

Sisymbrium filiquis declinatis, foliis pinnatis : foliolis subcordatis. Syft. Nat.

WATERCRESS. Blossoms white. In springs and running brooks of water. May.

It is an early and wholesome spring salad, and is used as a pot-herb. Dr. *Witbering* says, it is an excellent antiscorbutic and stomachic, with less acrimony than the *fourvygrafs*. It is an ingredient in the antiscorbutic juices.

SINAPIS. Linn. Gen. Plant.

Sinapis filiquis glabris tetragonis. Syft. Nat.

BLACK MUSTARD. Blossoms pale yellow. Common about barns. June.

The imported mustard, so common at tables, and which is generally preferred to our own, is the pulverized seed of this species;—the difference consists only in the preparation of the powder. The seeds unbruised are frequently given in palsies and chronic rheumatisms, and are found beneficial. They may be taken in the quantity of a table-spoon full, or more, and will gently relax the bowels. Rheumatic pains in the stomach are often relieved by taking them in brandy. The powdered seeds, with crumbs of bread and vinegar, are made into cataplasms, and applied to the soles of the feet in fevers, when stimulants are necessary. They are also topically applied in fixed rheumatic and sciatic pains. Dr. *Witbering* says, wherever we want a strong stimulus, that acts upon the nervous system without exciting much heat, we know none preferable to the mustard seed. An infusion of the seed, given in large quantities, vomits; but in smaller doses, operates as an aperient and diuretic. Mustard whey, with wine, is used as a drink in fevers. Its acrimony is said to consist in an essential oil.

RAPHANUS. Linn. Gen. Plant. 736.

Raphanus filiquis teretibus articulatis levibus unilocularibus.
Syft. Nat.

CHARLOCK.

CHARLOCK. Blossoms white or yellow. Common amongst rye, barley and flax. June—August.

It is often very injurious to grain; and when it has once got into the ground it is extremely difficult to extirpate. The seeds will remain in the ground many years, in a vegetive state, after it is swarded over with grass, and will grow when the ground is again plowed up. Dr. *Withering* says, in wet seasons it grows in great quantity amongst the barley in *Sweden*; and the common people, who eat barley bread, are afflicted with very violent convulsive complaints in those provinces, and in those seasons wherein this plant abounds.

MONADELPHIA.

DECANDRIA

GERANIUM. Linn. Gen. Plant. 746.

Geranium pedunculis subtrifloris, foliis cordatis crenato-incisis subvillosis, caulibus procumbentibus. Syst. Nat.

SEA CRANESBILL. Blossoms pale red. In marshes and on the sea shore. June—July.

Geranium pedunculis bifloris, calycibus inflatis, pistillo longissimo. Syst. Nat.

COMMON CRANESBILL. Blossoms purple. By stone walls and borders of fields. May—July.

The root is astringent, and frequently used in gargles for cankerous sores in the mouth and throat.

Geranium pedunculis bifloris, calycibus pilosis decemangulatis. Syst. Nat.

MOUNTAIN CRANESBILL. *Herb-Robert.* *Stockbill.* Blossoms pale red. Amongst rocks in high land. June—July.

It is considerably astringent, and smells somewhat like musk. A decoction of the plant has been known to give relief in calculous

culous cases. It is given to cattle when they make bloody water.

POLYANDRIA.

ALTHÆA. Linn. Gen. Plant. 749.

Althæa foliis simplicibus tomentosis. Syst. Nat.

MARSH-MALLOW. Blossoms purplish white. In marshes on Martha's Vineyard. August.

It is common in gardens, where it is cultivated for its medical virtues. The whole plant is mucilaginous, but the mucilage abounds most in the roots. It is much used in cataplasms and fomentations as an emollient. An infusion, or decoction, is commonly ordered in all cases which require mild mucilaginous substances.

MALVA. Linn. Gen. Plant. 751.

Malva caule repente, foliis cordato-orbiculatis obsolete quinquelobatis. Syst. Nat.

MALLOW. Blossoms white, tinged with purple. Common about barns. June—September.

DIADELPHIA.

OCTANDRIA.

POLYGALA. Linn. Gen. Plant. 761.

Polygala floribus imberbibus oblongo-capitatis, caule erecto herbaceo simplicissimo, foliis lanceolatis acutis. Syst. Nat.

MILKWORT. Blossoms red and yellow. Common in moist fields. August—September.

This plant is generally called *Low Centaury*, and has, probably, been mistaken for a species of the *Gentiana*.

Polygala.

LONG-SPIKED MILKWORT. Stems erect; branched. Leaves lanceolate. Blossoms in long terminating spikes; pale red. In moist land. Not common. August.

DECANDRIA.

DECANDRIA.

GENISTA. Linn. Gen. Plant. 766.

Genista foliis lanceolatis glabris, ramis striatis teretibus erectis.
Syft. Nat.

GREENWOOD. Dyer's Weed. Wood Waxen. Blossoms yellow.
In pastures between New-Mills and Salem. June.

The blossoms afford a yellow colour. The powdered seeds
operate as a mild purgative. A decoction of the plant is diuretic.

ÆSCHYNOMENE. Linn. Gen. Plant. 769.

Æschynomene caule hispido, leguminum articulis semicordatis,
bracteis cordatis ciliatis, stipulis utrinque lanceolatis. Syft. Nat.

TOOTH-PODDED BEAN. Blossoms pale red. On the borders
of fields. August.

LUPINUS. Linn. Gen. Plant. 774.

Lupinus calycibus alternis appendiculatis: labio superiore bi-
partito, inferiore integro. Syft. Nat.

LUPINE. Blossoms blue. In corn fields, in the state of Con-
necticut. June—August.

ROBINIA. Linn. Gen. Plant. 775.

Robinia pedunculis subdivisis, foliis pinnatis, floribus foliolo
majoribus. Syft. Nat.

LOCUST-TREE. Blossoms white. In the woods in the south-
ern states—only by cultivation here. June.

The wood, when green, is of a soft texture, but becomes
very hard when it is thoroughly dry. It is as durable as the
best white oak, and esteemed preferable for carriage axletrees,
trannels for ships, and for many other mechanic purposes. It
makes excellent fuel, and its shade is less injurious to grass than
that of most other trees. It may be propagated with great ease
and to very advantageous purposes.

PISUM.

PISUM. Linn. Gen. Plant. 779.

Pisum petiolis supra planiusculis, caule angulato, stipulis sagittatis, pedunculis multifloris. Syft. Nat.

SEA PEA. Blossoms pale red and purple. On sandy beaches near the sea. July—August. They are esculent.

Pisum petiolis decurrentibus membranaceis diphyllis, pedunculis unifloris. Syft. Nat.

PIED PEA. Blossoms red, purple and white. In rich moist land. June—July.

OROBUS. Linn. Gen. Plant. 780.

Orobis pinnatis ovatis stipulis semisagittatis integerrimis, caule simplici. Syft. Nat.

PEASELING. Blossoms purple. Near New-Mills in Danvers. June—July.

Orobis foliis pinnatis lanceolatis, stipulis semisagittatis integerrimis, caule simplici. Syft. Nat.

WOOD PEAS. Heath Peas. Blossoms red and yellow. In shrub-oak and pine land. July.

It is said, that the roots, when boiled, are savory and nutritious—Ground into powder, they may be made into bread.—That they are held in high esteem by the Highlanders in Scotland, who chew them as people do tobacco, and find that they prevent the uneasy sensation of hunger. They imagine, that they promote expectoration, and are very efficacious in curing disorders of the lungs. They know how to prepare an intoxicating liquor from them.

Orobis caulibus decumbentibus hirsutis ramosis. Syft. Nat.

WOOD PEASELING. Blossoms redish white. Borders of wood land. July.

LATHYRUS.

LATHYRUS. Linn. Gen. Plant. 781.

Lathyrus pedunculis multifloris, cirrhis diphyllis : foliolis ovalibus, internodiis nudis. Syst. Nat.

VETCHLING. Blossoms purple. Sandy beaches. July.

Lathyrus pedunculis multifloris, cirrhis polyphyllis, stipulis ovatis : basi acutis. Syst. Nat.

CHICKLING PEAS. Blossoms purple and white. In Salem, near the sea. July.

VICIA. Linn. Gen. Plant. 782.

Vicia leguminibus pedicellatis subquaternis erectis, foliolis ovatis integerrimis : exterioribus decrepcentibus. Syst. Nat.

VETCH. Blossoms purple. Borders of fields. July.

INDIGOFERA. Linn. Gen. Plant. 794.

Indigofera leguminibus horizontalibus teretibus, foliis pinnatis ternatisque ? Syst. Nat.

INDIGOWEED. Blossoms yellow. Common in pastures and woods. July—August.

A durable pale blue may be obtained from the leaves and small branches. Fomentations of the plant, it is said, will abate the swelling, and counteract the poison in the bite of rattle-snakes.

TRIFOLIUM. Linn. Gen. Plant. 802.

The indigenous species of this genus are too numerous to admit of a particular description. Several of them are generally known, viz. The *Melilot Clover*. The *Creeping Clover*. The *White Honeysuckle*. The *Red Honeysuckle*. The *Yellow Clover*. The *Woolly-headed Clover*, or *Chuckle-head*. The *Tall Trefoil*.

MEDICAGO. Linn. Gen. Plant. 805.

GROUND NUT. The germen is rolled inwards, but the pod becomes nearly strait, containing several kidney-shaped seeds.

M m m

Stems

474 Mr. CUTLER's Account of indigenous Vegetables,

Stems twining. Blossoms in clusters, placed in the axilla of the leaves; red or red and white. Common in leamy wood-land. July.

The roots are roundish and esculent, and were eaten by the Indians.

POLYADELPHIA.

POLYANDRIA.

HYPERICUM. Linn. Gen. Plant. 808.

Hypericum floribus trigynis: petalis calyce sublongioribus, foliis ovali-oblongis obtusis semiamplexicaulibus, caule tereti. Syst. Nat.

TUTSAN. All Saint's Wort. Blossoms pale red. Moist land. August.

Hypericum floribus trigynis, caule quadrato herbaceo. Syst. Nat.

St. PETER'S WORT. Blossoms yellow. Moist meadows. July.

Hypericum floribus trigynis, caule ancipiti, foliis obtusis pel- lucido-punctatis. Syst. Nat.

St. JOHN'S WORT. Blossoms yellow. In fields. July—Aug.

The small dots upon the leaves, which appear like so many perforations, are said to contain an essential oil. The leaves are given to destroy worms. The flowers tinge spirits and oil of a fine purple colour.

SYNGENESIA.

POLYGAMIA EQUALIS.

SONCHUS. Linn. Gen. Plant. 813.

Sonchus pedunculis hispidis, floribus racemosis, foliis lyrato-bas- tatis. Syst. Nat.

SAWTHISTLE. Blossoms purple. On ditch banks. August—September.

LACTUCA.

475
botanically arranged.
LACTUCA. Linn. Gen. Plant. 814.
Lactuca foliis laciniato-ensiformibus dentatis inermibus. Syft.
Nat.

WILD LETTUCE. Milkweed. Blossoms yellow. About barns
and fields. August—September.

The milky juice is said to possess the properties of opium.
It may be collected in shells, dried by a gentle heat, and made
into pills.

PRENANTHES. Linn. Gen. Plant. 816.
*Prenanthes flosculis plurimis, floribus nutantibus subumbellatis,
foliis hastato-angulatis.* Syft. Nat.

IVYLEAF. Ivy-leaved Wild Lettuce. Snake-weed. Blossoms
white. By stone walls in rich moist land. August.

LEONTODON. Linn. Gen. Plant. 817.
Leontodon calyce inferne reflexo. Syft. Nat.
DANDELION. Blossoms yellow. Grass land. May—Sept.
The leaves, early in the spring, are much esteemed as a pot-
herb and in fallads. It is sometimes transplanted into gardens,
and blanched like endive. The French eat the roots and leaves
with bread and butter. It is in a considerable degree diuretic.
Boerhaave had a great opinion of the utility of this and other
lactescent plants in obstructions of the viscera. The expressed
juice is said to have been given, to the quantity of four ounces,
three or four times a day.

HIERACIUM. Linn. Gen. Plant. 829.
*Hieracium caule multifloro, foliis lyratis glabris, calyce pedun-
culisque hispids.* Syft. Nat.

HAWKWEED. Blossoms yellow. About barns and rubbish.
August.

Hieracium caule erecto multifloro, foliis lanceolatis dentatis, pedunculis tomentosis. Syft. Nat.

RATTLE-SNAKE PLANTAIN. *Poor Robin's Plantain.* Blossoms pale yellow. The radical leaves are of a reddish colour, and spread on the ground like plantain. In woods. June—Aug.

It is said to have been considered by the Indians as an infallible cure for the bite of rattle-snakes. They chewed the leaves in the mouth, and, after swallowing part of the juice, applied them to the wound. This is, probably, the plant which *Carver* says the Indians were convinced was such a powerful antidote, that for a trifling bribe of spiritous liquors, they would at any time permit a rattle-snake to drive his fangs into their flesh.

CREPIS. Linn. Gen. Plant. 819.

Crepis involucris calyce longioribus: squamis setaceis sparsis. Syft. Nat.

BLUE SUCCORY. Blossoms blue. Fields in Cambridge. July. It is said to be a good stomachic.

Crepis involucris ovatis concavis obtusis patentibus. Syft. Nat.

YELLOW SUCCORY. Blossoms yellow. Wood land. August.

ARCTIUM. Linn. Gen. Plant. 830.

Arctium foliis cordatis inermibus petiolatis. Syft. Nat.

BURDOCK. Blossoms purple. About barns. July—Aug.

The young stems boiled, divested of the bark, are esteemed little inferior to asparagus. They are also eaten raw with oil and vinegar. Dr. *Withering* says, a decoction of the roots is esteemed, by some very sensible physicians, as equal, if not superior, to that of sarsaparilla.

SERRATULA

SERRATULA. Linn. Gen. Plant. 831.

Serratula foliis lanceolatis, squamis calycinis apice membranaceis obtusis patulis coloratis, floribus terminalibus. Syft. Nat.

DEVIL'S BIT. The root appears as if bitten off. Blossoms purple. Old fields. August—September.

In England, a plant of the fourth class is called *Devil's Bit*, the *Scabiosa succisa*. Linn. *Morsus diaboli vulgaris, flore purpureo.* Park. An infusion of the roots of this plant, in a close vessel, has been found very serviceable in scrophulous complaints.

CARDUUS. Linn. Gen. Plant. 832.

Carduus foliis sinuatis decurrentibus: margine spinosis, calycibus pedunculatis solitariis erectis villosis. Syft. Nat.

WELTED THISTLE. Blossoms pale red. Road sides. July.

Carduus foliis sessilibus bifariam pinnatifidis: laciniis alternis erectis, erectis, calycibus globosis villosis. Syft. Nat.

STAR THISTLE. Friar's Crown. Blossoms purple. In pastures. July—August.

Carduus foliis pinnatifidis spinosis sessilibus, caule inermi, floribus solitariis. Syft. Nat.

LADIES THISTLE. Blossoms purple. Road sides. July.

Carduus foliis lanceolatis dentatis amplexicaulibus: spinulis inaequalibus ciliatis, caule inermi. Syft. Nat.

YELLOW THISTLE. Blossoms yellow. In Chelsea. June.

The flowers of thistles have the property of rennet in curdling milk.

CARLINA. Linn. Gen. Plant. 836.

Carlina caule multifloro corymbose, floribus terminalibus. Syft. Nat.

FIRE-WEED. Blossoms white. It abounds in new plantations where the ground has been burnt over. Aug. **BIDENS.**

BIDENS. Linn. Gen. Plant. 840.

Bidens foliis pinnatis ferratis glabris, seminibus erectis, calycibus frondosis, caule lævi. Syft. Nat.

HARVEST-LICE. Cuckold. Blossoms yellow. In corn fields. September.

EUPATORIUM. Linn. Gen. Plant. 842.

Eupatorium foliis quaternis scabris lanceolato-ovatis inæqualiter ferratis petiolatis rugosis. Syft. Nat.

LIVER-HEMP. Honefty. Hemp Agrimony. Blossoms pale red. In moist land, by brooks and rivers. July—August.

Dr. Withering says, an infusion of an handful of it, vomits and purges smartly. An ounce of the root, in decoction, is a full dose. In smaller doses the Dutch peasants take it as an alterative and an antiscorbutic.

Eupatorium foliis connatis tomentosis. Syft. Nat.

THOROUGH-WAX. Blossoms white. In moist land. July—August.

The *Bupleurum rotundifolium*. Linn. The *Perfoliata vulgaris*. Park. of the fifth class, is called *Thorough-wax* in England. An infusion of the leaves is a powerful emetic.

AGERATUM. Linn. Gen. Plant. 843.

Ageratum foliis ovatis crenatis obtusis, caule glabro. Syft. Nat.

MEADOW SUNFLOWER. Blossoms yellow. In wet meadows. September.

STÆHELINA. Linn. Gen. Plant. 844.

Stæhelina foliis subtrigonis, squamis calycinis crenatis. Syft. Nat.

PRICKLY DEVIL'S-BIT. Blossoms purple. On Winter-Hill in Charlestown. July—August.

POLYGAMA

POLYGAMIA SUPERFLUA

TANACETUM. Linn. Gen. Plant. 848.

Tanacetum foliis bipinnatis ferratis. Syft. Nat.

TANSET. Blossoms yellow. Pastures. August.

The leaves are frequently used to give a colour and flavour to pudding. Fresh meat may be preserved from the attacks of the flesh-fly, by rubbing it with this plant. It is considered as a warm deobstruent bitter. The *Finlanders* are said to obtain a green dye from it.

ARTEMISIA. Linn. Gen. Plant. 849.

Artemisia foliis compositis multifidis, floribus subglobosis pendulis: receptaculo villosa. Syft. Nat.

WORMWOOD. Blossoms brownish white. Road sides, and amongst rubbish. July—August.

The leaves and flowers are well known to be bitter, and to resist putrefaction. They are made a principle ingredient in antiseptic fomentations. The roots are warm and aromatic. The plant affords a considerable quantity of essential oil, by distillation, which is used both internally and externally to destroy worms. Fomentations, or cataplasms of the leaves are sometimes applied to the bellies of children in obstinate worm cases. An infusion of the leaves is said to be a good stomachic, and with the addition of fixed alkaline salt, a powerful diuretic in dropical cases. *Linnaeus* has mentioned two cases, wherein an essence, prepared from this plant, and taken for a considerable time, prevented the formation of stones in the kidneys and bladder—the patients forbearing the use of wine and acids. If women, that suckle, take an infusion of this plant, it makes their milk bitter. The leaves put into four beer, soon destroy the acescency.

Artemisia

Artemisia foliis pinnatifidis planis incisis subtus tomentosis, racemis simplicibus, floribus ovatis : radio quinquefloro. Syft. Nat.

MUGWORT. Blossoms purplish. Borders of fields. Aug.

Dr. Withering says, in some countries it is used as a culinary aromatic. A decoction of it is taken by the common people to cure the ague.

GNAPHALIUM. Linn. Gen. Plant. 850.

Gnaphalium foliis semiamplexicaulibus ensiformibus repandis obtusis utrinque pubescentibus, floribus conglomeratis. Syft. Nat.

CATSFoot. Woolly Mouse-Ear. Blossoms yellowish white. Road sides. August.

Gnaphalium foliis decurrentibus obtusis mucronatis utrinque tomentosis planis. Syft. Nat.

LIFE-EVERLASTING. Blossoms white. In pastures and fields. September.

NONE-SO-PRETTY. Stems herbaceous ; branched. Leaves ovate ; slightly serrated ; sessile ; alternate. Blossoms in broad topped spikes ; redish purple. Female florets in the circumference, and without petals.

ERIGERON. Linn. Gen. Plant. 855.

Erigeron ramis lateralibus multifloris, calycibus squarrosis. Syft. Nat.

FLEABANE. Florets in the circumference white ; those in the center purple. By fences. August.

Erigeron caule floribusque paniculatis. Syft. Nat.

MEADOW FLEBANE. Florets in the circumference white ; those in the center yellow. Moist land. August—September.

Erigeron pedunculis alternis unifloro. Syft. Nat.

ROSEBETTY. Blossoms in the circumference purple ; those in the center yellow. By fences. August—Sept.

TUSSILAGO.

TUSSILAGO. Linn. Gen. Plant. 856.

Tussilago scapo imbricato unifloro, foliis subcordatis angulatis denticulatis. Syst. Nat.

COLTSFOOT. Blossoms yellow. About barns. April.

Dr. Withering says, the leaves are the basis of the British herb tobacco.—They are somewhat austre, bitterish, and mucilaginous to the taste. They have been much used in coughs and consumptive complaints. Dr. Cullen has found them to do considerable service in scrophulous cases.—He gives a decoction of the dried leaves, and finds it succeed where sea-water has failed.

SENECIO. Linn. Gen. Plant. 857.

Senecio corollis radiantibus, foliis ensiformibus acute serratis subtus subvillosis, caule stricto? Syst. Nat.

GROUNDSEL. Stanchbodd. Blossoms in branched particles; white. Borders of corn fields. August—October.

This plant has been found very efficacious in stopping hemorrhages in certain persons, subject to a very singular kind of constitutional bleeding, when other means have failed. If the bleeding be occasioned by the rupture of internal blood-vessels, they drink a strong decoction of the plant: if it be external, they both drink the decoction, and apply to the wound the fresh leaves bruised, or the dried plant in form of a poultice.

ASTER. Linn. Gen. Plant. 858.

Aster foliis linearibus integerrimis, caule paniculato. Syst. Nat.

BUSHY ASTER. Florets in the circumference white, tinged with red; in the center yellow. By fences. September.

Aster foliis linearibus acutis integerrimis, caule corymboso ramosissimo. Syst. Nat.

DWARF ASTER. Florets in the circumference purple ; in the center yellow. In hedges. August.

Aster foliis lanceolatis integerrimis semiamplexicaulibus, floribus confertis terminalibus, pedunculis nudis, caule hispido. Syft. Nat.

NEW-ENGLAND ASTER. Florets in the circumference purple ; in the center yellow. Borders of fields. Aug.—Sept.

SOLIDAGO. Linn. Gen. Plant. 859.

Solidago paniculato-corymbosa, racemis recurvatis, floribus ascendentibus, foliis trinerviis subserratis scabris. Syft. Nat.

ROUGH-LEAVED GOLDENROD. Blossoms yellow. Borders of fields. August.

Solidago paniculato-corymbosa, racemis recurvis, floribus ascendentibus, foliis enerviis, subintegerrimis. Syft. Nat.

SMOOTH-LEAVED GOLDENROD. Blossoms yellow. Borders of fields. August.

Solidago caule obliquo, pedunculis erectis foliolatis ramosis, foliis lanceolatis integerrimis. Syft. Nat.

MARSH GOLDENROD. Blossoms yellow. Borders of marshes. August.

INULA. Linn. Gen. Plant. 860.

Inula foliis ovatis rugosis subtus tomentosis, calycum squamis ovatis. Syft. Nat.

ELECAMPANE. Blossoms yellow. Road sides. August.

Dr. Withering says, the root is esteemed a good pectoral. Dr. Hill says, he knows, from his own experience, that an infusion of the fresh root, sweetened with honey, is an excellent medicine in the whooping cough.

CHRYSANTHEMUM

CHRYSANTHEMUM. Linn. Gen. Plant. 866.

Chrysanthemum foliis amplexicaulibus oblongis : superne serratis ; inferne dentatis. Syft. Nat.

WHITE WEED. *Goldens. Daisie.* Florets in the circumference white ; in the center yellow. In fields and pastures. May—June. The young leaves may be eaten as fallad. It is very injurious to grass land.

ANTHEMIS. Linn. Gen. Plant. 876.

Anthemis receptaculis conicis : paleis setaceis, seminibus nudis. Syft. Nat.

MAY-WEED. Florets in the circumference white ; in the center yellow. Road sides. June—August.

It is said to be grateful to toads, and very ungrateful to bees.

ACHILLEA. Linn. Gen. Plant. 871.

Achillea foliis bipinnatis nudis : laciniis linearibus dentatis. Syft. Nat.

NARROW. Blossoms white. In dry pastures. June—Aug.

Dr. Withering says, the flowers yield an essential oil :—that the leaves are celebrated by the *materia medica* writers for a variety of purposes, but they are little attended to at present.

POLYGAMIA FRUSTRANEA.

HELIANTHUS. Linn. Gen. Plant. 877.

Helianthus foliis oppositis sessilibus ovato-oblongis trinerviis panicula dichotoma. Syft. Nat.

ROUGH-LEAVED SUNFLOWER. Blossoms yellow. Borders of fields. August—September.

It is, in a considerable degree, astringent. A decoction of the plant is much esteemed by the common people in diarrhæas.

RUDBECKIA ? Linn. Gen. Plant. 878.

AMERICAN GLOBE AMARANTHUS. The leaves lanceolate ; alternate ; sessile ; downy. Stems woolly. Blossoms globular.

484 Mr. CUTLER'S Account of indigenous Vegetables;

Barren florets numerous; entire; white.—Fertile florets small; yellow. They stand in a broad-topped spike. The blossoms are durable after they are taken off. It makes a pretty appearance in flower borders. In high, rich pastures. Aug.—Oct.

COREOPSIS. Linn. Gen. Plant. 879.
Coreopsis foliis pinnatis serratis, radio florum diversicolore.
Syst. Nat.

MEADOW CUCKOLD. Blossoms yellow, red, and white. In wet meadows. August.

MONOGAMIA.

LOBELIA. Linn. Gen. Plant. 897.
Lobelia caule erecto, foliis lanceolato-linearibus obtusiusculis alternis integerrimis, racemo terminali. Syst. Nat.

SPINET. Blossoms blue. In moist grass land. June—July.

Lobelia caule erecto, foliis lanceolatis serratis spica terminali.
Syst. Nat.

AMERICAN PRIDE. Blossoms scarlet. Borders of brooks and rivers. August.

Lobelia.

EMETICWEED. The leaves oblong; slightly serrated; sessile; alternate; on the upper surface numerous tubercles. Stems branched. Blossoms solitary; in a kind of spike; pale blue. Common in dry fields. August.

The leaves chewed in the mouth are, at first, insipid, but soon become pungent, occasioning a copious discharge of saliva. If they are held in the mouth for some time, they produce giddiness and pain in the head, with a trembling agitation of the whole body: at length they bring an extreme nausea and vomiting. The taste resembles that of tartar emetic. A plant possessed

possessed of such active properties, notwithstanding the violent effects from chewing the leaves, may possibly become a valuable medicine.

VIOLA. Linn. Gen. Plant. 898.

Viola acaulis, foliis pinnatifidis. Syst. Nat.

MOUNTAIN VIOLET. Blossoms variegated. On the hills in Lynn. October.

Viola acaulis, foliis reniformibus. Syst. Nat.

MARSH VIOLET. Blossoms pale blue. In moist meadows. April.

Viola acaulis, foliis cordatis, stolonibus reptantibus. Syst. Nat.

SWEET VIOLET. Blossoms deepish purple. In moist warm land. April.

The flowers and the seeds are said to be mild laxatives. The leaves give the blue colour to the sirup of violets, which is changed by an acid to red, and by an alkali to green. It is said, that slips of white paper stained with the petals, and kept from the air and the light, will be changed in the same manner.

Viola caule erecto, foliis cordatis-acuminatis. Syst. Nat.

YELLOW VIOLET. Blossoms yellow. In shady places. May.

It is said the Indians applied the bruised leaves to boils and painful swellings, for the purpose of easing the pain and producing suppuration.

IMPATIENS. Linn. Gen. Plant. 899.

Impatiens pedunculis multifloris solitariis foliis ovatis, geniculis caulinis tumentibus. Syst. Nat.

WEATHERCOCK. Balsamine. Touch-me-not. Quick-in-the-Hand. Blossoms yellow. Banks of rivulets. July—Aug.

It

It is generally known here by the name of *Celandine*, and is much celebrated among the common people for curing the jaundice.

GYNANDRIA.

DIANDRIA.

ORCHIS. Linn. Gen. Plant. 900.

Orchis nectarii cornu setaceo longitudine germinis: labio tripartito cilari. Syft. Nat.

LADY'S PLUME. Female-banded Orchis. Blossoms in large spikes; white, or purplish, or flesh-colour'd. In wet meadows. August.

OPHRYS. Linn. Gen. Plant. 902.

Ophrys bulbis aggregatis oblongis caule subfolioso, floribus secundis, nectarii labio indiviso. Syft. Nat.

TRIPLE LADY'S TRACES. Blossoms in a spiral spike; yellowish white. In moist land. August.

ARETHUSA? Linn. Gen. Plant. 905.

Arethusa radice globosa, scapo vaginato, spatula diphylla. Syft. Nat.

RED-WINGED ORCHIS. Blossoms red or purple. In mossy meadows. August.

CYRRIPEDIUM. Linn. Gen. Plant. 906.

Cyrripedium radicibus fibrosis, foliis ovato-lanceolatis caulinis. Syft. Nat.

LADY'S SLIPPER. The petals red. *Nectarium* flesh-colour'd, with dark red veins. In moist shady places. May—June.

Catesby says, the flowers of this plant, which are very singular, were in great esteem with the Indians for decking their hair.

hair. They called it the *Meccasin Flower*. It is easily propagated in gardens by transplanting the roots, which are perennial.

TRIANDRIA.

SISYRINCHIUM. Linn. Gen. Plant. 908.

Sisyrrinchium caule foliisque ancipitibus. Syst. Nat.

BLUE-EYED GRASS. Blossoms blue. In grass land. May—June. It makes very pretty edging for borders in gardens.

POLYANDRIA.

ARUM. Linn. Gen. Plant. 915.

Arum acaule, foliis hastato-cordatis acutis : angulis obtusis. Syst. Nat.

CUCKOWPINT. Dragon-root. Wake-Robin. Lords & Ladies. *Spatha* striped with red or black. Berries red.

The fresh root is extremely acrid. The dried root, grated into water, is frequently given as a carminative. It is said the Indians boiled both the shreded roots and berries with their venison. Dr. *Withering* says, the root has been employed in medicine as a stimulant, but when reduced to powder it looses much of its acrimony ; and there is reason to suppose, that the compound powder which takes its name from this plant, owes its virtue chiefly to the other ingredients ;—that there is no doubt but the acrid quality of the plant may be turned to very useful purposes ; but we must first learn how to ascertain its dose. He says, the root, dried and powdered, is used by the *French* to wash their skin with.—It is sold at a high price, under the name of *Cypress Powder*.—It is undoubtedly a good and an innocent cosmetic.—When the acrimony of the roots is extracted, by boiling or baking, they afford a very mild and wholesome nourishment.—Many nations prepare the only bread they have from plants as acrimonious as this ; first dissipating the

the noxious qualities by the force of heat.—Starch may be made from the roots.

CALLA. Linn. Gen. Plant. 917.

Calla foliis cordatis, spatba plana, spadice undique hermaphrodito. Syst. Nat.

HEART-LEAF FLAG. *Spatba* on the inner side white. Stamina yellow. Berries red. In watery places.

MONOECIA.

MONANDRIA.

ZANNICHELLIA. Linn. Gen. Plant. 920.

ODDITY. Stems hairy; erect. Leaves ovate; slightly serrated; alternate. Blossoms in pairs in the *axillæ* of the leaves. The calix tinged with red. In pastures. September.

ELATERIUM. Linn. Gen. Plant. 1036. 6 Edit.

WILD CUCUMBER. The stems, leaves and blossoms like those of the cucumber. Hampton falls, in the state of New-Hampshire. August—September.

TETANDRIA.

BETULA. Linn. Gen. Plant. 933.

The limits of this paper will admit of giving only the English names of this and the following genera of trees.—The *White Birch*. The *Black Birch*. The *Alder*, or *Owler*.

URTICA. Linn. Gen. Plant. 935.

Urtica foliis oppositis ovalibus. Syst. Nat.

NETTLE. *Stinging Nettle*. The leaves are deeply serrated.

The young shoots, early in the spring, are a good pot-herb. A leaf put upon the tongue, and pressed against the roof of the mouth, is said to be efficacious in stopping a bleeding at the nose.

nose. The parts affected in paralytic cases have been recovered by stinging them with this plant. Dr. *Withering* says, the stings are very curious microscopic objects.—They consist of an exceeding fine pointed, tapering, hollow substance, with a perforation at the point, and a bag at the base. When the sting is pressed upon, it readily punctures the skin; and the same pressure forces up an acrimonious fluid from the bag, which instantly squirts into the wound, and produces an effect which almost every one has experienced. The stalks are dressed like flax, for making cloth or paper. The leaves cut fine, and mixed with dough, are very good for young turkeys.

PENTANDRIA.

AMBROSIA. Linn. Gen. Plant. 938.

Ambrosia foliis bipinnatifidis: racemis paniculatis terminalibus glabris. Syft. Nat.

CONOT-WEED. Roman Wormwood. In great plenty on the borders of cultivated fields. September.

It is generally called *Roman Wormwood*, and seems to have been mistaken for the *Artemisia maritima*. Linn. It has somewhat the smell of camphire. It is used in antiseptic fomentations. When it abounds amongst rye or barley, the seeds are thrashed out with the grain, and will give bread, made of it, a bitter and disagreeable taste.

AMARANTHUS. Linn. Gen. Plant. 941.

Amaranthus racemis pentandris compositis erectis foliis oblongo-ovatis. Syft. Nat.

HOG-WEED. White Amaranthus. Amongst rubbish. August.

Amaranthus racemis pentandris compositis patulo-nutantibus, foliis lanceolato-ovatis. Syft. Nat.

BLOODY AMARANTHUS. *Love-lies-a-bleeding.* *Princes Feather.* Amongst rubbish. August.

A decoction of this plant, drank freely, has been found efficacious in uterine hæmorrhages, when other powerful styptics have failed.

POLYANDRIA.

QUERCUS. Linn. Gen. Plant. 949.

The *White Oak.* The *Red Oak.* The *Yellow Oak.* The *Grey Oak.* The *Black Oak.* The *Swamp Oak.* The *Chestnut Oak.* The *Shrub Oak.*

JUGLANS. Linn. Gen. Plant. 950.

The *White Walnut.* The *Red-hearted Walnut.* The *Oil Nut,* or *Butter Nut.*

FAGUS. Linn. Gen. 951.

The *Larger Chestnut.* The *Smaller Chestnut,* with egg-shaped nuts. The *Beech.*

CARPINUS. Linn. Gen. Plant. 952.

The *Horn Beam.*

CORYLUS. Linn. Gen. Plant. 953.

The *Round-shelled Hazle.* The *Long-shelled Hazle.*

LIQUIDAMBAR. Linn. Gen. Plant. 955.

Liquidambar foliis oblongis sinuatis. Syst. Nat.

SWEET FERN. A small shrub. Common in dry pastures. July—August.

MONADELPHIA.

PINUS. Linn. Gen. Plant. 956.

The *White Pine.* The *Yellow Pine.* The *Pitch Pine.* The *Norway Pine.* The *White Cedar.* The *Red Cedar.* The *Fir.* The *Hemlock.* The *Spruce.* The *Tassamahac.*

DIOECIA.

DIOECIA.

DIANDRIA.

SALIX. Linn. Gen. Plant. 976.

The *White Willow*. The *Red Willow*. The *Rose Willow*.
The *Dogwood*. The *Osier*.

An account is given, in the Transactions of the Royal Society, (vol. liii. p. 195) by the Rev. Mr. Stone, of the great efficacy of white willow bark in curing intermitting fevers. He gathered the bark in summer, when it was full of sap;—dried it by a gentle heat, and gave a dram of it powdered, every four hours betwixt the fits. In a few obstinate cases he mixed it with one fifth part of *Peruvian* bark. Some judicious physicians, here, have made trial of the bark of the white willow, and recommend it as a valuable substitute for the *Peruvian* bark. They have used principally the bark of the roots.

HEXANDRIA.

SMILAX. Linn. Gen. Plant. 992.

Smilax caule inermi tereti, foliis inermibus: caulinis cordatis, ramis ovato-oblongis? Syst. Nat.

BIND-WEED. Bramble. Blossoms greenish white. Berries black. In moist hedges. June.

OCTANDRIA.

POPULUS. Linn. Gen. Plant. 996.

The *White Poplar*. The *Trembling Poplar*, or *Aspen Tree*.
The *Black Poplar*, commonly called, in the northern states, the *Balm of Gilead*.

POLYANDRIA.

CLIFFORTIA. Linn. Gen. Plant. 1004.

Cliffortia foliis ternatis: intermedio tridentato. Syst. Nat.

THREE-LEAVED CLIFFORTIA. Snake-weed. In moist land.
May—June.

POLYGAMIA.

MONOECIA.

VERATRUM. Linn. Gen. Plant. 1013.

Veratrum racemo supradecomposito, corollis erectis. Syst. Nat.

WHITE HELEBORE. Poke-root. Indian Poke. Common in wet meadows and swamps. June.

The root is a most drastic cathartic and sternutatory. The fresh roots, beaten up with hog's lard, cures the itch. It is said, the roots are poisonous to swine. Crows may be destroyed by boiling Indian corn in a strong decoction of the fresh roots, and strewing it on the ground where they resort.

ACER. Linn. Gen. Plant. 1023.

The Great Maple, or Sycamore Tree. The Rock Maple. The Sugar Maple.

DIOECIA.

FRAXINUS. Linn. Gen. Plant. 1026.

The White Ash. The Red Ash. The Black Ash. The Prickley Ash.

PANAX. Linn. Gen. Plant. 1031.

Panax foliis ternis quinatis. Syst. Nat.

GINSENG. Ninsin. It is said to grow plentifully in some parts of this, and in some of the neighbouring states. May—June.

This plant is the famous *panacea* of the Chinese, to which they have recourse in all diseases, as the last remedy. The European physicians esteem it a good medicine in convulsions, vertigoes, and all nervous complaints, and recommend it as one of the best restoratives known. Its dose is from ten grains to twenty, in powder; and from one dram to two to the pint, in infusions. An infusion of the leaves is drank among the Chinese and Tartars, by people of distinction, instead of tea; but

it

it is too dear for the common people to use. The dried roots and leaves are said to be sold amongst them for three times their weight in silver. The young roots are preferred to the old. They collect the roots only in the spring and fall. They are washed in a decoction of millet seed, and then suspended over the fumes of the same liquor, in a close vessel, while it is boiling. After this, they dry it for use; and when dried, it becomes almost transparent. The young fibres which are taken off, they boil in water, and make an extract of them, which they use in the same intention with the root. From the quantity that grows in this country, and the demand for it in the *East-Indies*, and other parts of the world, we have reason to hope it will become a valuable export.

The indigenous plants of the twenty-fourth class, whose flowers are inconspicuous, are too numerous to be described in this paper.



You

XXV. *A Letter on the Retreat of House-Swallows in Winter, from the Honourable SAMUEL DEXTER, Esq; to the Honourable JAMES BOWDOIN, Esq; Pres. A. A.*

Dedham, June 3, 1783.

DEAR SIR,

AMONG more important branches of natural history, with which you are conversant, ornithology cannot have escaped your notice.

I know it has been a problem among naturalists, whether certain species of birds emigrate in autumn to distant countries, and return in the spring, or remain with us during the winter, in a torpid state; and that the former opinion has generally prevailed. When, therefore, I acquaint you that I have adopted the latter, with respect to the *house-swallow*, you will justly expect that I give you substantial reasons for differing from so many who have maintained the contrary.

The late Judge *Foster*, of *Brookfield*, a year or two before his death, assured me, that he saw a certain pond drained, about the season of the year when the swallows first appear. The business being effected, and the weather fair and warm, he, with several others, observed a rippling motion in many parts of the emptied hollow; which, on a near inspection, they found to be occasioned by a multitude of swallows, endeavouring to disengage themselves from the mud, which was scarcely covered by the shallow remains of water.

I shall now mention some other facts, which render it probable, that this sort of swallows sink into ponds and rivers, in the fall of the year, and lie there, benumbed and motionless, until the return of spring.

You

You know, Sir, that my house is near a large river. This river is, in many parts, shallow, and has a muddy bottom. A former neighbour of mine, a plain, honest and sensible man, now deceased, who lived still nearer to the river, used frequently to say to me, as the warm weather came on in the spring, "it is almost time for the swallows to come out of the mud, where they have lain all winter." On my calling his philosophy, once and again, in question, and saying, as I formerly believed, that doubtless they were birds of passage, he has repeatedly assured me, he had, in the autumn of many years, seen great numbers of them, on one day only in each year, and nearly about, but not always on the same day of the month, sitting on the willow bushes, (which, by the way, they are not wont to roost upon at other times) on the borders of the river, a little after sunset :—That they seemed as if their torpitude had already begun, as they would not stir from the twigs, which, by the weight of the swallows, were bent down almost to the water ;—and that although he had never seen them sink into it, yet he had waited till it was so dark that he could not discern them at all ; and doubted not of their immersion any more than if he had been a witness of it ; for he had never observed any flying about afterwards, till the return of spring. He added, that if, as he wished, I would carefully look out for their resurrection, he believed it would not be in vain. He had, he said, often taken notice that only a few appeared at first, and the main body in about a week after.

Although I paid little regard to it for some years, yet I followed his advice at length, and watched for their appearance several seasons, as carefully as I could. I have not indeed beheld them rising out of the water ; yet I and my family have, in
more

more years than one, seen, at the proper time in the spring, very large flocks of them, in my own, and in my neighbour's land, so near the margin of the river, that, from that circumstance, the appearance of their feathers, and their being unable to use their wings as at other times, we concluded they were newly emerged from the water. When they attempted to fly, they could not reach above eight or ten yards before they settled to the ground, and then might be drove about like chickens. They appeared unwilling to be disturbed; and, if not frightened by some noise or motion, would cluster together, seeming to want to rest themselves, as if feeble, or fatigued.—They were not entirely recovered from their stupor,—there was a viscous substance on and about their wings,—or they were too weak to fly away. We had seen none in those years before; but in each of them, after a day or two, they were flying about as usual in summer.

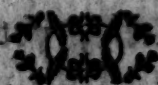
In addition to the foregoing, I can assure you, on the most credible testimony, that there have been more instances than one of a pickerel's being caught in this river, at the season of the coming of swallows, with one of those birds in its belly.

I may possibly overrate these discoveries, yet, as I cannot overrate your candour, I hope to lose no credit by communicating them to an old and faithful friend, who, though he should not be informed, may possibly be amused by them.

I am, with the sincerest esteem,

Sir, your most obedient servant.

SAMUEL DEXTER.



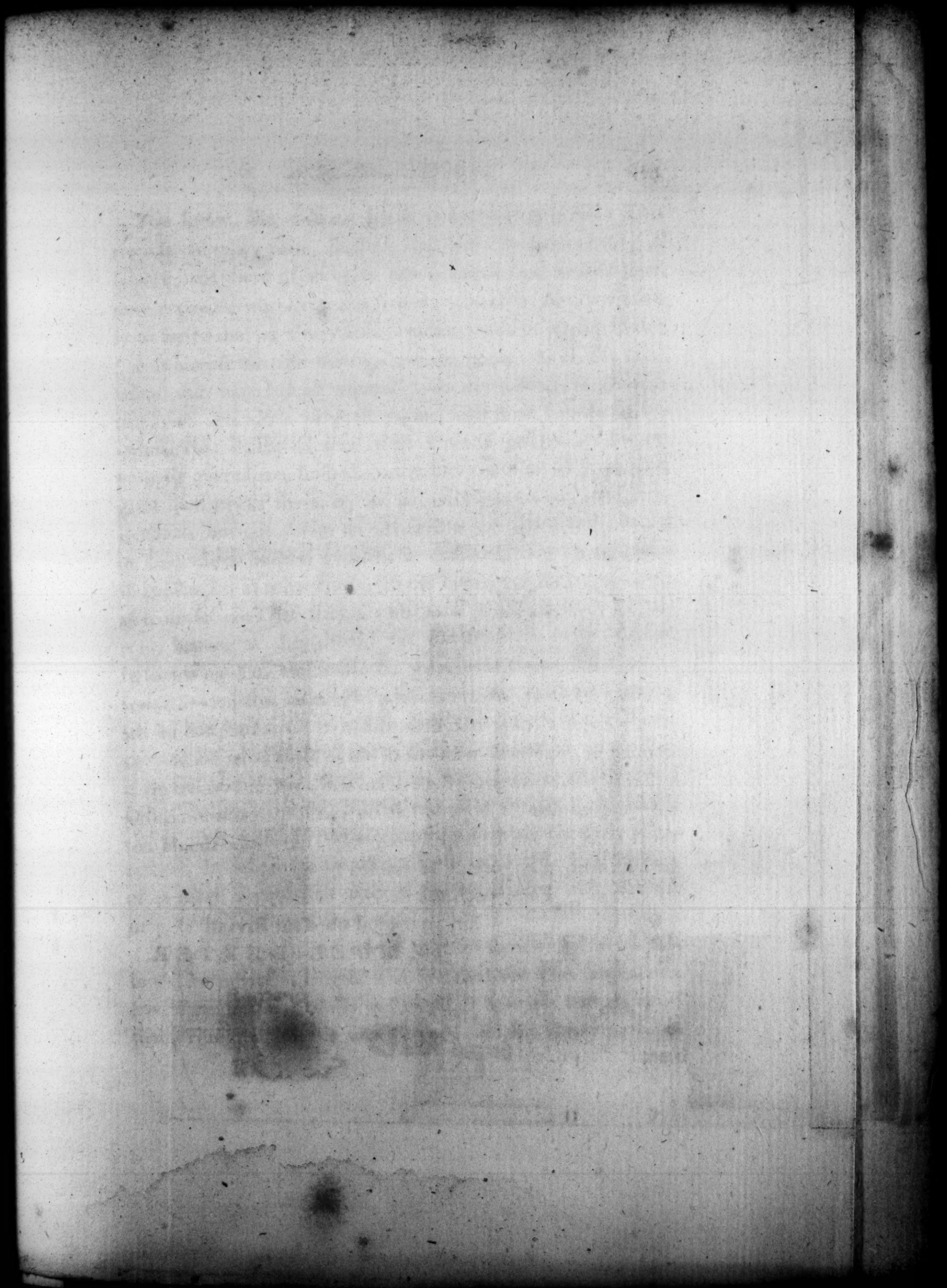


Plate 4

AIR PUMP

Fig. I

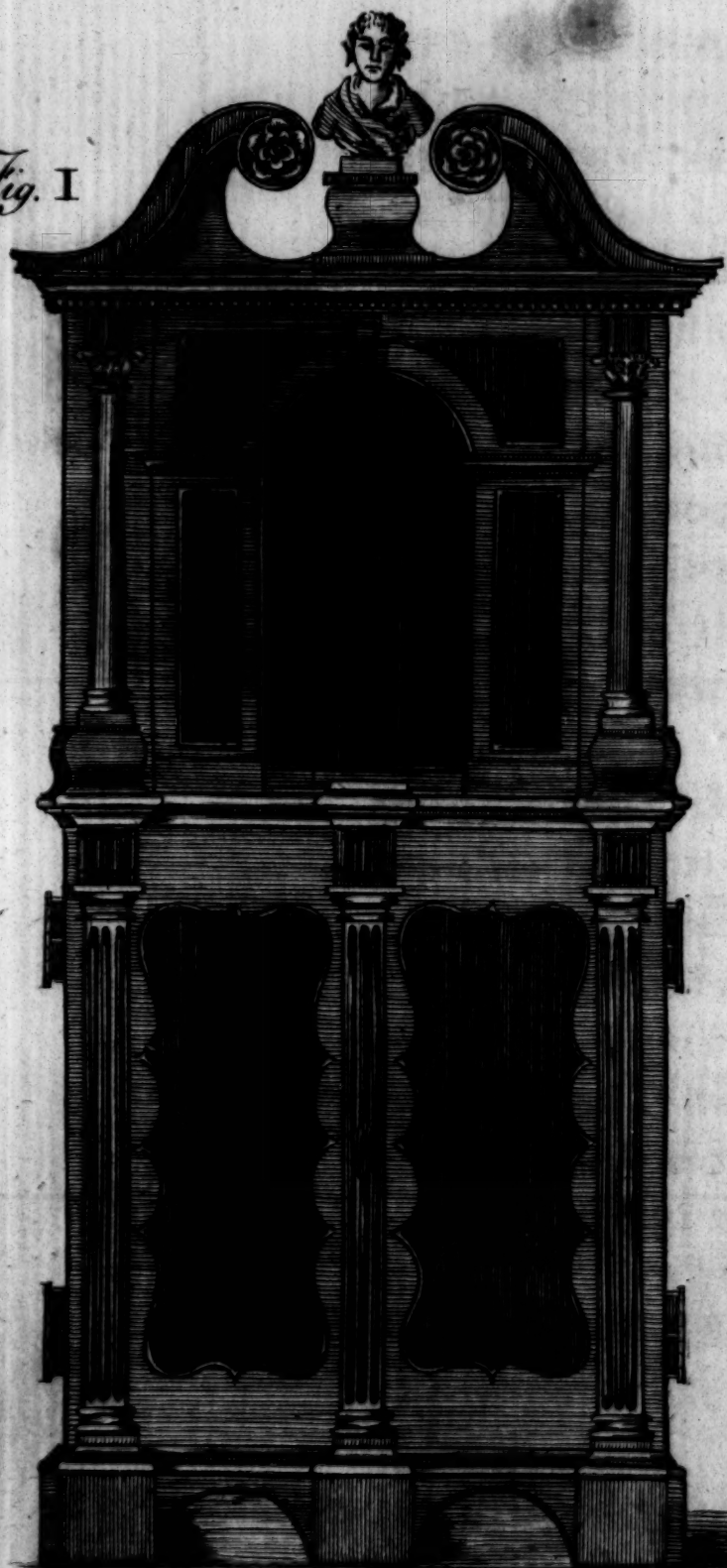


Fig. II

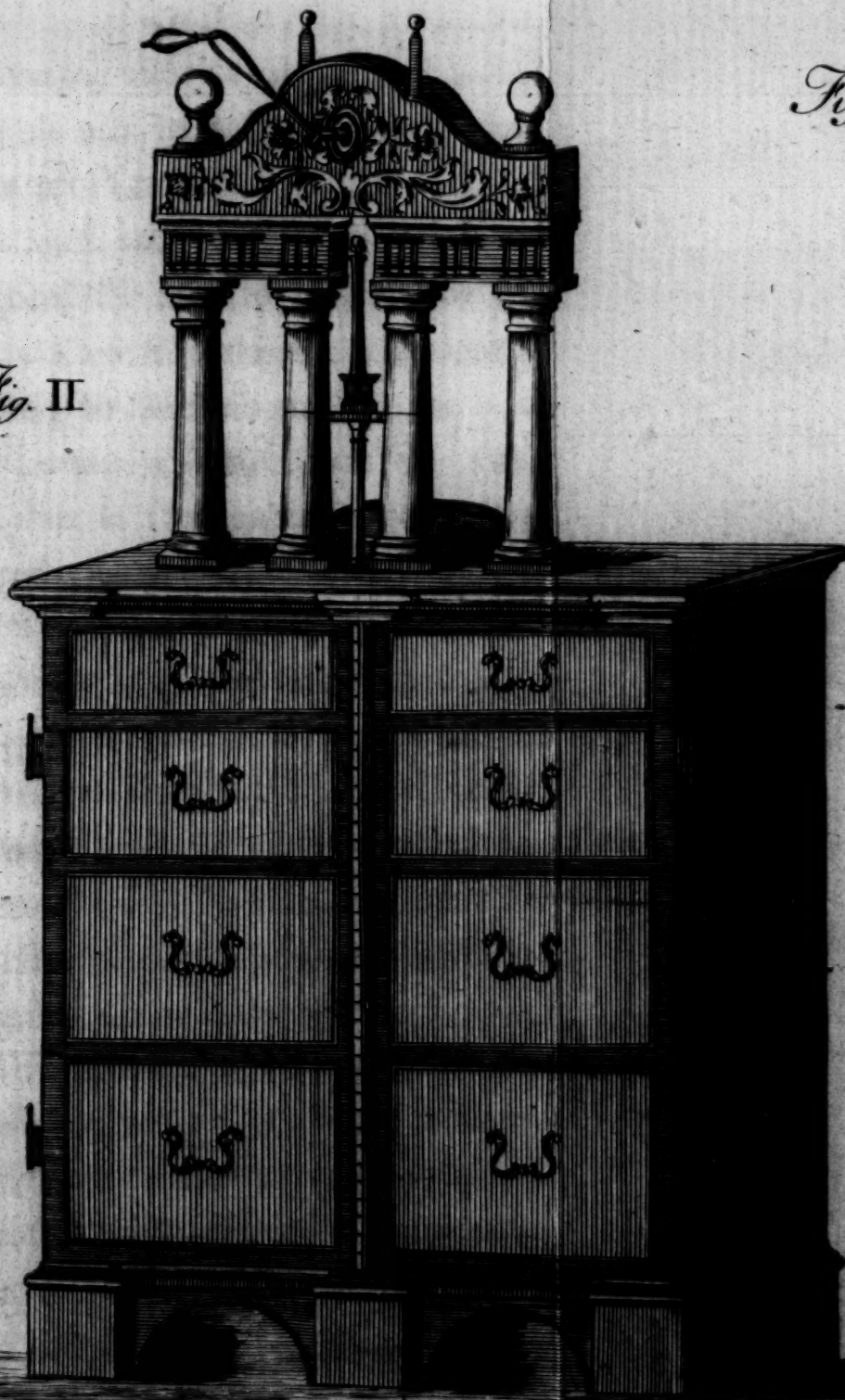
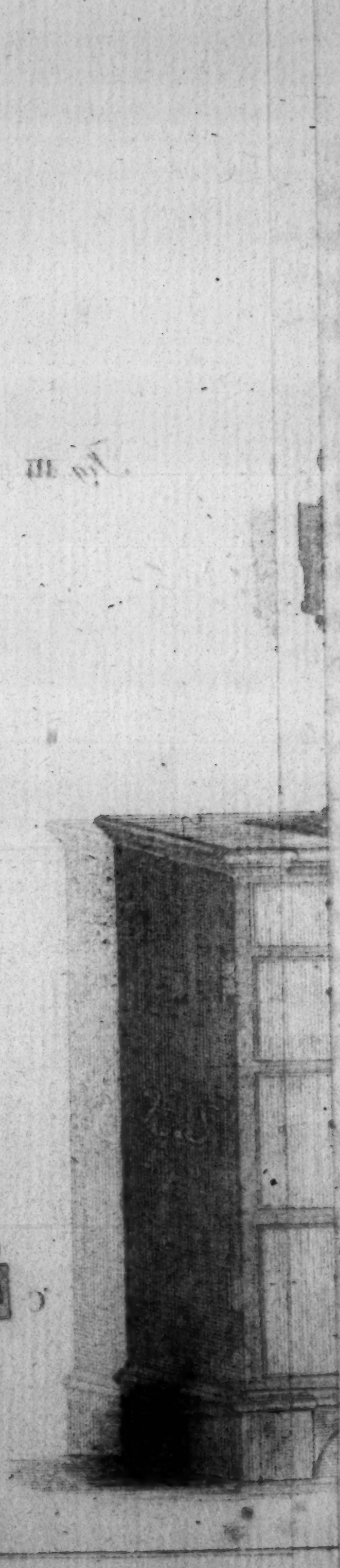
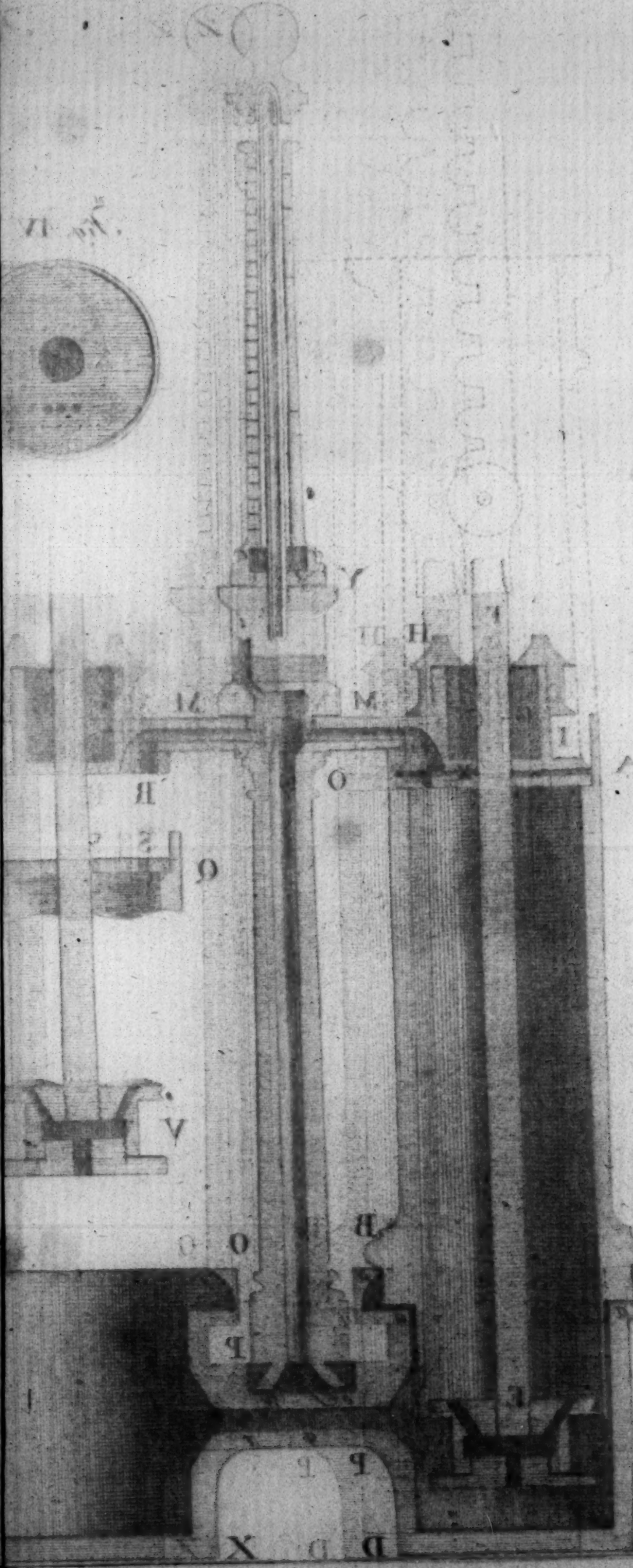
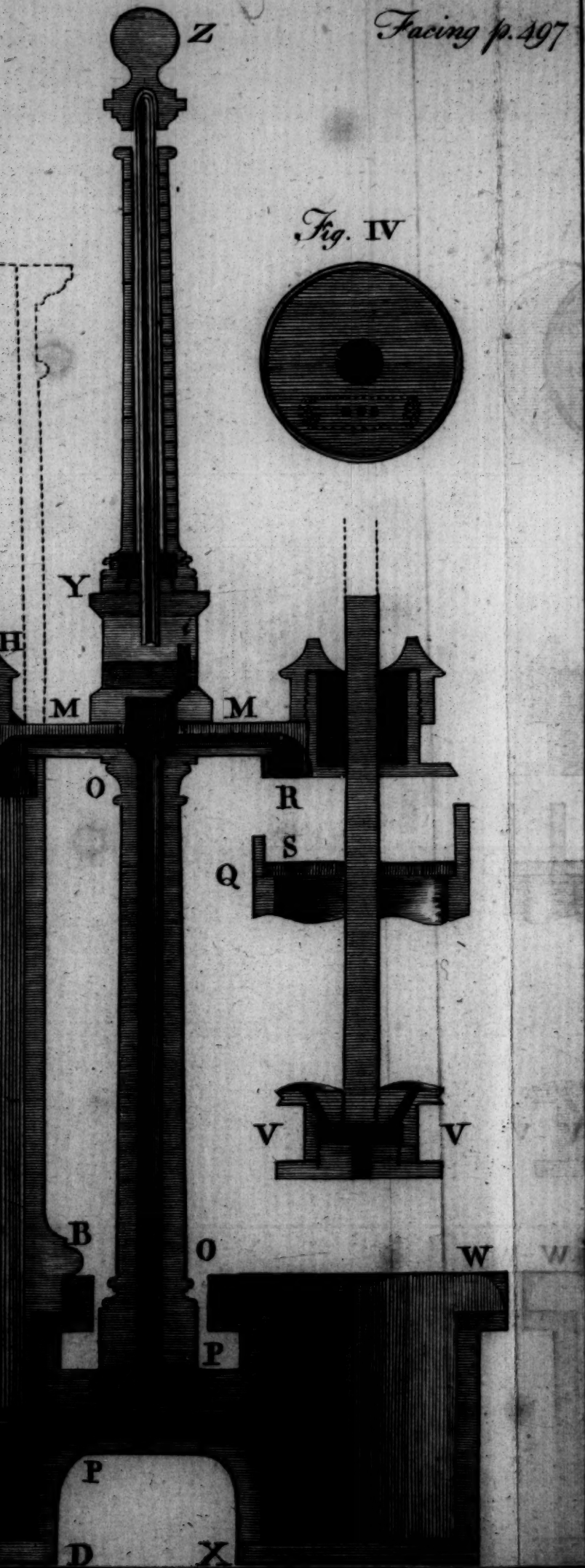


Fig. III



Facing p. 497

Fig. IV



XXVI. *An Account of an Air-Pump on a new Construction; with some Observations on the common Air-Pump, and Mr. SMEATON'S improvement: In a Letter from the Rev. JOHN PRINCE to the Rev. JOSEPH WILLARD, President of the University of Cambridge.*

Salem, Nov. 10, 1783.

REV. AND DEAR SIR,

AGREEABLE to your request, I will endeavour to give you some account of the air-pump I have lately constructed, upon a plan different from any I have ever seen.

Reading the account of the ingenious Mr. Smeaton's air-pump, in vol. xlviii. of the Philosophical Transactions, and the high recommendation of it by Dr. Priestley, in vol. lxiv. of the same work, I was desirous of possessing one of that kind: but finding, by the Doctor's paper, they were not commonly made by the philosophical instrument-makers in London, it induced me to attempt making one myself, with such assistance as I could get here.

Before I had proceeded far, I thought Mr. Smeaton's pump might be improved, if not in its power of rarifying the air, at least in simplicity. With this in view, I have finished mine. To show the ground on which I have gone, it will be necessary to consider the rationale of an air-pump, and make some observations on Mr. Smeaton's. It is well known that the valve at the bottom of the barrel of an air-pump is opened by the spring of the air acting against it underneath, when the weight of the air is removed from the top of the valve, by raising the piston in the barrel. In order to remove this resistance from the top of the valve most effectually, the piston should be made to fit very exactly to the valve-plate, when put down upon it: for if there be any space between the bottom of the piston and

P p p

valve,

valve, part of the air will be retained in it; and this air, even when the piston is raised to the highest, will, by its expansion, in some measure, obstruct the opening of the valve. When the air in the receiver, or underneath the valve, is rarefied to an equal degree with the air contained in the barrel, (the piston being drawn up to the highest) the valve can rise no longer, because the resistance above is equal to the power below. The resistance from this air, retained in the barrel, against the valve at the bottom, will be uniformly the same, when the piston is at the same distance from it; because the weight of the atmosphere is continually pressing on the piston-valve, and will prevent the air below passing through it, while this air is rarer than the atmosphere: and when the piston is put down to the bottom of the barrel, it will not escape through the piston, but only be compressed into the vacancy between the bottom of the piston and the valve-plate at the bottom of the barrel, and be of equal density with the atmosphere. Besides the resistance arising from this retained air, we must consider the weight of the valve, its cohesion to the plate, occasioned by the oil, and its being stretched tight over the hole, as increasing the obstruction; especially when the spring of the air under the valve is much weakened by rarefaction. And if we take into the account the resistance arising from these causes, the density of the air in the barrel, when compressed into the abovementioned vacancy, will be as much greater than the density of the atmosphere above the piston, as the addition of this resistance; for this obstruction belongs to the piston-valve, as well as to the other. And so also, when this retained air is expanded, say one hundred times, by raising the piston, the air in the receiver cannot be rarefied to the same degree, because of this resistance of the valve at the bottom of the barrel.

In

In order to produce a greater rarefaction of the air in the receiver than what the common pump will effect, the valves, where used, must be made to open easier, by removing, as far as possible, these obstructions. In the common pump these impediments are great; because the surface of the valve, which is exposed to the air underneath, is generally very small; and the vacancy between the piston and the bottom of the barrel bears a greater proportion to the whole barrel than it would if the work were properly executed.

These imperfections Mr. *Smeaton* considered and endeavoured to remove in the construction of his pump. For this purpose he exposed a much larger surface of the lower valve to the air underneath, by forming a kind of grating in the plate. By this the cohesion was lessened, and more power could apply to open the valve in the first instant. The difficulty arising from the air retained in the barrel he removed, in a great measure, by making the piston fit more nicely to the bottom, and by taking the weight of the atmosphere from off the piston, which allowed the valve in it to be more easily opened, so that much more of the air could pass through it. The weight of the atmosphere he removed from the piston, by closing the top of the barrel with a plate, on which he fixed a collar of leathers; through this the cylindrical part of the piston-rod moves air-tight. And the air, having passed through the piston, is forced out of the barrel through a hole in the top-plate, over which is a valve to prevent the return of air, when the piston descends. The piston is made to fit as exactly to the top, as to the bottom of the barrel, to exclude the air more effectually.

By this improvement, Mr. *Smeaton* says, "I have been able to rarefy the air one thousand times, when the pump was put

“ clean together ; and that it seldom failed of doing it five hundred, after it had been used for several months without cleaning : whereas the degree of rarefaction produced by the best common pumps never exceeded one hundred and forty times, when tried by my gage.”

I have taken up much of your time in this account ; but I hope you will not think unnecessarily, as it shows the ground on which I have gone, and a description of Mr. *Smeaton's* pump is, in some measure, a description of mine.

Mr. *Smeaton* having done so much to facilitate the opening of the valves, at the bottom of the barrel, and in the piston, by which means he carried the degree of rarefaction much further than the common pump could do ; I supposed, if those valves were entirely removed, and the remaining air in the barrel could be more perfectly expelled, the rarefaction might be carried still further. Upon this plan I have constructed my pump. I have removed the lower valve, and opened the bottom of the barrel into a cistern, on which it is placed, and which has a free communication with the receiver. For the valve on the plate, at the top of the barrel, (which is constructed like Mr. *Smeaton's*) makes it unnecessary there should be any at the bottom, in order to rarefy the air in the receiver.

The cistern is deep enough to allow the piston to descend into it, below the bottom of the barrel. Suppose then the piston to be solid ; that is, without a valve in it ; when it enters the barrel and rises to the top plate, which is made air-tight with a collar of leathers, &c. like Mr. *Smeaton's*, it forces out all the air above it ; and as the air cannot return into the barrel, on account of the valve on the top-plate, when the piston descends there will be a vacuum formed between that and the plate ;

plate; every thing being supposed perfect. But in working the pump, the piston is not allowed to descend entirely into the cistern, so far as to leave the bottom of the barrel open; because, as the cistern, for another purpose, is made larger than the bore of the barrel, this might make the piston-rod work unsteadily in the collar of leathers, and cause it to leak: but it descends below a hole in the side of the barrel, near the bottom, which opens a free communication between the barrel, cistern, and receiver. Through this hole the air rushes from the cistern into the exhausted barrel, when the piston has dropped below it; and by its next ascent this air is forced out as the other was before. If now the capacity of the receiver, cistern, pipes, &c. below the bottom of the barrel, taken together, be equal to the capacity of the barrel, half the remaining air will be expelled by every stroke.

But as the working a pump of this kind, with a solid piston, would be laborious, on account of the resistance it would meet with in its descent from the air beneath, (though this would be lessened by every stroke, as the air became more rarefied) I have, to remedy this inconvenience, pierced three holes in the piston, at equal distances from each other; and a circular piece of bladder, which is tied over the top of the piston, to make the joint more perfect with the top-plate, and to defend them from injury when the piston is brought up against it, forms a kind of valve over the holes, which open easy enough to prevent any labour in working the pump, as it allows the air to pass through the piston when it descends. But the air does not necessarily depend upon a passage through the piston in order to get into the barrel: for when the air becomes so weak, from its rarefaction, that it cannot open this valve, it will still get into the barrel.

rel when the communication is opened by the hole at the bottom. This piston, therefore, will descend as easy as any other; and this valve does not impede the rarefaction; since it is of no consequence, as to this, whether it open or not. By this construction, the valves, which Mr. *Smeaton* only made to open with more ease, are rendered unnecessary in rarefying the air: and that at the bottom of the barrel, which is the most difficult to be made and kept in order, is entirely removed; that on the top-plate being the only one necessary in rarefying the air.

But as in a single barrelled pump of this construction, where there is no valve at the bottom to prevent the air, which follows up the piston in its ascent, from returning into the receiver in its descent, a fluctuation would be produced, which might prove detrimental in some experiments, this pump is made with two barrels, which rarefies the air at every stroke of the winch. In this construction, the capacity of the two barrels, taken together, below the pistons, is always the same; for while one is descending, the other is ascending; and what is taken from the one is added to the other.

Having thus set aside the valves, which in some measure prevented the air from getting into the barrel and above the piston, I next attempted to expel the air more perfectly out of the barrel than Mr. *Smeaton* has done, by making a better vacuum between the piston and the top-plate, which would allow more of the air to expand itself into the barrel from the receiver. But to show in what manner I have attempted this, it will be necessary to give some further description of the machine.

I have, upon Mr. *Smeaton's* plan, contrived to connect the valves on the top-plates with the receiver, occasionally, by means

means of a pipe and cock; by the turning of which, the machine may be made to exhaust or condense at pleasure. This is done in the following manner: There is a cross-piece laid over the valves, extending from one barrel to the other, which has a duct through it, connected with a small pipe standing between the barrels: through this pipe the air passes into a duct in the bottom-piece leading to the cock. In this piece is likewise the duct leading from the cistern to the cock; and with this cock also is connected the pipe leading to the receiver. The key is pierced with two holes in such a manner, that one of them will connect the pipe coming from the receiver with the duct in the bottom-piece leading to the cistern, or with the other leading to the valves, as may be required for exhausting, or condensing. The other hole through the key will open, occasionally, to the atmosphere, either of these ducts round the cock. So that having the direction of the air which passes through the valves, under the command of this cock, the pump may exhaust or condense at pleasure: for when the key connects the pipe from the receiver, and the duct leading to the cisterns together, the pump will exhaust; and when it connects the pipe with the duct leading to the valves, it will condense; as the other hole in the key, at the same time, opens to the atmosphere the duct leading to the cisterns, by which passage the air enters the barrel from the atmosphere, is forced out at the valves, and through the pipe and cock into the receiver. In this part of the machine which is contrived for condensation, I have, by an additional part, endeavoured to get the air more perfectly out of the barrel.

We have seen that Mr. Smeaton, by making the piston of his pump fit more exactly to the bottom of the barrel, and by shutting

shutting up the top to prevent the pressure of the atmosphere on the piston-valve, was able to get more of the air above it than could be effected in the common pump. But still the difficulty, though so far removed, remains in the top of the barrel: for as the piston cannot be made to fit so exactly to the top-plate, but that there will be some lodgment for air, it is impossible to expel it entirely; more, perhaps, might be expelled if the valve on the top could be made to open more easily, by removing the weight of the air from it; for the atmosphere, pressing on this valve, will prevent its opening freely, in the same manner as when pressing on the piston-valve, it obstructs the opening of that in the common pump.

The difficulty which Mr. Smeaton removed from the piston-valves, I have endeavoured to remove from the valve on the top-plate; that this valve, having the pressure of the atmosphere taken off, might open with the same ease as the piston-valve does in his pump. To effect this, there is connected with the duct on the bottom-piece, which conveys the air from the valves to the cock, a small pump of the same construction as the large one; having the barrel opening into a cistern, the piston-rod moving through a collar of leathers, and a valve near the top, through which the air is forced into the atmosphere. This piston is solid; because the diameter, being only half-inch, does not make it work hard. This pump, which is of one barrel only, I call the valve-pump; its chief use being to rarefy the air above the valves, or remove the weight of the atmosphere from off them. To use this pump, it is necessary the key of the cock should be pierced differently from that of Mr. Smeaton's; for as the pipes round his are placed at equal distances, when the one from the bottom of the barrel is connected with

with that from the receiver to exhaust it, the other, from the valve on the top-plate, is opened to the atmosphere by the other passage through the cock. But in order to rarefy the air above the valve in my pump, it is necessary this last passage should be shut up, when the valve-pump is used. Instead, therefore, of placing the three ducts at equal distances round the cock, I have divided the whole into five equal parts; leaving the distance of one-fifth between the ducts leading from the cistern and the valves to the cock, and two-fifths between each of these and the one leading from the cock to the receiver. By this adjustment, when the communication is open between the receiver and valves, for condensation, the other hole through the cock opens the cisterns to the atmosphere: but when the communication is made between the cisterns and the receiver, for exhaustion, a solid part of the key comes against the duct leading to the valves, and shuts it up; and the air, which is forced out of the barrel, passes into the atmosphere through the valve-pump; for the valve of the small pump may be kept open while the great one is worked.

Now, to apply Mr. *Smeaton's* reasoning to this construction. After mentioning his taking off the weight of the atmosphere from the piston, by shutting up the top of the barrel, he says, "The consequence of this construction is, that when the piston is put down to the bottom of the cylinder, the air in the lodgement under the piston will evacuate itself so much the more, as the valve of the piston opens more easily, when pressed by the rarefied air above it, than when pressed by the whole weight of the atmosphere. Hence, as the piston may be made to fit as nearly to the top of the cylinder, as it can to the bottom, the air may be rarefied as much above the piston

" as it could before have been in the receiver. It follows,
 " therefore, that the air may now be rarefied in the receiver,
 " in duplicate proportion of what it could be upon the com-
 " mon principle; every thing else being supposed perfect."
 The same may be said with regard to the valve on the top-plate
 in this machine. It will open more easily, when pressed by
 the rarefied air above it, than when pressed by the weight of
 the whole atmosphere. Hence, as by the construction of the
 valve-pump the air may be rarefied as much above the valves,
 as it could before have been in the barrel and receiver, with
 which there is a free communication: it therefore follows, that
 the air may now be rarefied in the receiver in duplicate propor-
 tion of what it could be by Mr. Smeaton's pump; every thing
 else being supposed perfect; and the nature of the air permit-
 ting it.

In this estimation, any advantage which may arise from the
 removal of the valves at the bottom of the barrels and in the
 piston, is not considered: But if they made any resistance in
 Mr. Smeaton's pump, may we not conclude, that the rarefac-
 tion might be carried further by a machine wherein no such
 valves are made use of? Mr. Smeaton says, that when he
 contrived to open his valves by the winch, independent of the
 spring of air, he did not find it answer the purpose better than
 when the air was the agent. There is no reasoning against ex-
 periment: but it certainly appears probable from theory, that
 there must be considerable resistance from the valves when the
 air is greatly rarefied.

He afterwards says, " the degree, to which I have been able
 " to rarefy the air, by experiment, has generally been about one
 " thousand times, when the pump is put clean together: but
 " the

“ the moisture that adheres to the inside of the barrel, as well
“ as the other internal parts, upon letting in the air, is, in the
“ same succeeding trials, worked together with the oil, which
“ soon renders it so clammy as to obstruct the action of the
“ pump, upon a fluid so subtle as the air is, when so much
“ expanded.—But in this case it seldom fails to act upon the
“ air in the receiver, till it is expanded five hundred times : and
“ this I have found it to do, after being frequently used for several
“ months without cleaning.” Does it not appear probable, that
this clamminess must have a bad effect upon the valves, as well as
the other internal parts of the pump, in those same succeeding
trials ? and that the stiffness which the oil acquires by evapora-
tion, the corrosion of the brass, &c. when the pump is foul,
must greatly obstruct the opening of the valves, and bear a prin-
ciple part in reducing the rarefaction from one thousand to five
hundred times ?

I supposed the valves to be a great obstruction, and have en-
deavoured to avoid them : and if no farther advantage be de-
rived from it, the machine is more simple without them.

Upon this construction, also, we are able to make the pump
with two barrels, like the common pump, which cannot be
done conveniently where the lower valve is retained ; because it
would be difficult to make the piston in one barrel come ex-
actly to the bottom, at the same time that the piston in the
other touched as exactly at the top : it would, at least, require
a nicety in the workmanship, which would be troublesome to
execute.

In this pump, the pistons do not move the whole length of
the barrels : there is a horizontal section made in them, a little
more than half way from the bottom, where the top-plates are

inserted. By this mean the pump is made more convenient and simple, as the head of it is brought down upon the top of the barrels, in the same manner as in the common air-pump. The barrels also stand upon the same plane with the receiver-plate; and this plane is raised high enough to admit the common gage of thirty-two or three inches, to stand under it, without any inconvenience in working the pump, as the winch moves thro' a less portion of an arch, at each stroke, than it would if the pistons moved the whole length of the barrels.

There is also placed, between the barrels in this pump, on the cross-piece over the valves, a gage to measure the degree of condensation, having a free communication with the valves, cock, &c. This gage is so constructed, that it will also serve to measure the rarefaction above the valves, when the air is worked off by the valve-pump. It consists of a pedestal, which forms a cistern for the mercury, a hollow brass pillar, and glass tube, hermetically sealed at one end, which moves up and down in the pillar, through a collar of leathers. The dye of the pedestal is made of glass, as well to hold the quicksilver, as to expose its surface to view, that it may be seen when the open end of the tube is put down into it, or raised out of it. The body of the pillar is partly cut away to expose the tube to view in the same manner.

If the pump be used as a condenser, the degree of condensation is shown by a scale marked on one edge of the pillar: if it be used as an exhauster, the degree of the rarefaction of the air, above the valves, is shown by a scale marked on the other edge of the pillar.

This gage will also serve to show when the valves have done playing, either with the weight of the atmosphere on them,

or taken off. If we want to know when they cease opening, with the weight of the atmosphere on them, draw the piston of the valve-pump up into its barrel, to prevent any air escaping through that valve; in this situation, work the great pump again, and if any air passes through the valves into the pipe, the gage will rise by condensation. This condensed air must then be let out by opening the communication, at the cock, with the outward air. By repeating this till the gage rises no longer, we may know the valves will open no more while the weight of the atmosphere lies on them; and the rarefaction in the receiver can be carried no further. When the weight of the atmosphere is to be removed, after conducting as in the former experiment, raise the open end of the tube above the surface of the mercury, and then work the valve-pump, and the air will be rarefied over the valves, and in the tube, to the same degree: (we may see when the valve of this pump has done playing by unscrewing the cap that covers it.) The open end of the tube is then to be immersed into the mercury, and the great pump worked. The air which passes thro' the valves will then raise the gage by condensation: and thus, by alternately raising and depressing the tube, and working the two pumps in their turns, we may carry the rarefaction of the air in the receiver as far as the power of the pump will go. If one of Mr. Smeaton's pear-gages be used in the receiver, as he directs, the difference of the rarefaction, in the two experiments, may be known. And as the air above the valves may be rarefied to different degrees, we may know, by the two gages, what proportion the rarefaction above the valves bears to the degree of excess in the receiver. This condensing gage can be taken off, and a button screwed into the hole in its stead, in any case wherein a greater degree of condensation is required than

the

the glass will bear. When a glass receiver is used, this gage may be placed within it, where it will measure any degree of condensation the receiver will bear, without danger to the gage : or the capacity of any receiver may be measured by this gage, before it is removed from its place, by showing how many strokes of the winch will throw one atmosphere into the receiver ; then turning the cock, to prevent any air escaping, change the gage for the button : when this is done, the degree of condensation may be further measured by the number of strokes.

As in cases where great condensation is required, there must be a great deal of labour, and a great strain on the teeth of the wheel and piston-rods, on account of the great diameter of the pistons ; * to remedy this, I have fitted a condenser, of a smaller bore than the barrel of the great pump, to the cistern of the valve-pump, to be screwed on occasionally ; by which the condensation may be finished, instead of the great pump. Or, to save the work and expence of this condenser, the valve-pump, if made a little larger, may be easily fitted for the same purpose, by having a plate made to screw into the bottom of the cylinder, occasionally, with a valve on it, opening into the cistern : a hole must also be made to be opened, on the same occasion, near the top of the cylinder, to let air in below the piston, when this is drawn up above it.

The common gage, which is generally placed under the receiver-plate, in this pump, is placed in the front ; that it may be seen by the person who is working the pump, and that the plate may be left free for other uses.

The

* In my pump, the pistons are two inches diameter ; so that there will be about forty-eight pounds added to the resistance in opening the valves, for every atmosphere thrown into the receiver.

The plate is so fixed to the pipe, leading to the cock, that it may be taken off at pleasure, and used as a transferer; or any tube, or apparatus, may be fixed to it, to perform some experiments without removing it, which will save trouble, and make less apparatus necessary.

The head of this pump is not divided, as the common one is, to dislodge the teeth of the wheel from the piston-rods, when the pump is to be taken apart; but is made whole, except a small piece in the back, where the wheel is let in; which makes it much more convenient to remove the head, or place it on the barrels. The wheel is freed from the piston-rods, when required, by pushing it into the back part of the head; and when it is drawn into its place and connected with them again, a button is screwed into the socket of the axis behind, to keep it in its place. This makes the head less troublesome to remove: but its chief use is to dislodge the piston-rods from the wheel, that they may be put down into the cisterns, when the pump is not in use, where they will stand uncompressed, and retain their elasticity better than if kept in the barrels. In these cisterns they may also stand covered with oil, if necessary, as they are large enough to admit of it.

The principal joints of the pump are sunk in sockets, that the leathers, which close them, may be covered with oil, to prevent leaking.*

For convenience, the lower part of the pump is fitted with drawers, to contain the apparatus. A door opens behind one range

* This, I find, is very effectual: having never known one of the joints, secured in this way, to leak, though the pump has stood for a long time: whereas a portable pump which I have, made by Mr. Nairne, London, has leaked, and repeatedly been refitted with new-oiled leathers, in the same time.

range, to a place reserved the whole height, to get at the under part of the receiver-plate, and fix apparatus to it for some experiments. In this place stand the long tubes, and such tall glasses, belonging to the apparatus, as will not go into the drawers. The barrels, &c. of the pump are covered with a case, or head, which keeps them from dust and accident, when the pump is not in use. The apparatus is secured between flinders, &c. in the drawers, so that the whole machine may be easily removed, in one body, without danger.

Having given you this account of the machine, I wish, Sir, I could add to it, at this time, the result by experiment, and inform you to what degree it will rarefy the air; but the want of a proper apparatus to measure the rarefaction, prevents me.

As we have no glass-manufactory here, I sent to *Europe* for my apparatus, about twelve months since: but, unluckily, this part, with some others, have not yet been forwarded to me. As soon as I can satisfy myself, I will let you know the result. I have, at present, only a small tube of two-tenths inch bore, I accidentally met with, which I use as a common gage: but this will not determine the power of the pump.

All I can say of the instrument at present is, that I find it much more convenient to use than one of the common sort: that it will exhaust a receiver much sooner, and keep in order much longer, for being made without valves, which must depend on the spring of the air to open them. When a common pump, which I have, has been fitted up with valves, leathers, &c. at the same time with this; the valves of the common pump have become too dry and stiff to use, while this pump has continued in good order. I attribute this, in part, to the moisture which the valves on the top-plates receive from the pistons.

pistons every time the pump is used ; the pistons being always kept moistened with oil in the cisterns, where they stand when the pump is not in use ; and in part, to the power which the pistons have over these valves, by condensing the air against them. In the common pump, and in Mr. Smeaton's, the valves, at the bottom of the barrels, can only be opened by the spring of the air acting against them : but in this pump the valves are forced open, by raising the pistons, and must, therefore, yield much longer to the power applied in this way.

I mentioned above, that the pistons in this pump did not move the whole length of the barrels ; but were interrupted by the plate, a little more than half way from the bottom, for convenience : but on this construction, they may be made to move through the whole length, as in Mr. Smeaton's pump ; and then it will exhaust a receiver in half the time that his will, if the capacity of each barrel in the two pumps be equal. And perhaps the air may be further rarefied by a pump on this construction without the valves, whose barrels are of greater length than the barrels of my pump. For since the piston may be made to fit as well to the top of one barrel as another, if the length of the barrel, through which the piston moves, be twelve inches instead of six, the vacancy, which is unavoidably left between the top-plate and the piston, when the latter is drawn up to the former, will bear a less proportion to the capacity of the whole barrel. Suppose, then, the valve on the top-plate will rise only till the air be expanded one hundred times in a barrel of six inches length, because this is the proportion which the vacancy bears to the capacity of the whole barrel, (the resistance of the valve not being taken into the account) it will rise till the air is expanded two hundred times in a barrel of twelve inches

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length,

length, the diameters being the same in both, because the capacity of the barrel being doubled, the vacancy bears so much less proportion to it than to one of six inches. And if the air can be rarefied in proportion to the difference between the vacancy and the capacity of the barrel, by lessening this proportion, which, after having made the work to fit as well as possible, is to be done by enlarging the capacity of the barrel, the power of the pump must be increased.

This, Sir, is reasoning from theory : but these circumstances, I think, ought to be considered in the construction of an air-pump ; and experiment only must determine how far an attention to them may be useful.

The rarefaction which a pump will produce, by experiment, may come very far short of what it ought to do by the theory of its construction. If the common pump will, in experiment, rarefy the air only one hundred times, when in its best state, and Mr. *Smeaton's*, by construction, in duplicate proportion to this, it ought to go to ten thousand ; every thing being supposed perfect : but in its best state, Mr. *Smeaton's* pump will only rarefy the air about one thousand times ; so that the nine-tenths which it falls short of what it ought to do by theory, is to be attributed either to the imperfection of the machine alone, or to the nature of the air, in not permitting the rarefaction to go further than one thousand times, or both these causes together. The way to prove how far this is owing to the air itself, is by making a machine, which, in theory, will carry the rarefaction further. A pump constructed without the valves, as mine is, ought to rarefy the air in duplicate proportion of what Mr. *Smeaton's* should do by theory, and in quadruplicate proportion of the common pump, which would be one hundred million, allowing

allowing the common one to rarefy the air one hundred times. Nothing like this, however, is to be expected, since we see Mr. Smeaton's pump, in experiment, falls so far short of the theory. But supposing my pump to rarefy the air in duplicate proportion of what Mr. Smeaton's does by experiment, this would carry the rarefaction to one million times: and whatever it falls short of this, must be attributed either to the imperfection of the machine, or the nature of the air, or both together: or if this pump should rarefy the air only to the same degree with Mr. Smeaton's, since by construction it ought to go so much further, will it not ascertain to us, in a direct line, that the nature of the air does not admit of being further rarefied by a pump; and that this is the reason why Mr. Smeaton's pump, in experiment, fell so far short of the theory? If this should be the case, will it not be a confirmation that the power of mechanism is not wanting to produce a much greater rarefaction in the receiver, where no body acts immediately upon the air to expel it, and from which place it can only be induced to come, by making room for its expansion into some other? I hope, in a little time, to be able to inform you what the result is by experiment, and to what degree this pump will exhaust the receiver.

I am, &c.

JOHN PRINCE.

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AN

NOTE. Since this letter was communicated, I have seen, in the 67th vol. of the Philosophical Transactions, an account of some experiments made by Mr. Nairne, with a pump constructed on Mr. Smeaton's principle: from which it appears that Mr. Smeaton was deceived with respect to the rarefaction in his receiver, as indicated by the pear-gage; and that the greatest power of the pump, when the experiment was properly made, would carry the rarefaction in the receiver only to six hundred, instead

of

AN EXPLANATION OF THE PLATES.

PLATE IV. Fig. 1. A view of the pump shut up, when not in use; appearing through a glass window, as shewn by the pricked lines.

Fig. 2. A view of the pump when opened and uncovered for experiments.

Fig. 3. A perpendicular section of one of the barrels, the two cisterns, condensing gage, &c. where A B represents the barrel: C D the cistern on which it stands; *aaaa* the leathered joint, sunk into a socket, and buried in oil: E F is the piston; the cylindrical rod passing through a collar of leathers, G G, in the box H I. K shows the place of the valve on the top-plate K L, covered by the cross-piece M M, into which the pipe O O is soldered; that conveys the air from the valves to the duct going under the valve-pump, as may be seen in plate V. fig. 1. *o* is part of the said duct; *p* is the joint sunk into a socket in the cross-piece P P, which connects the cisterns and has a duct through it leading to them. Into this duct open the ducts *q* and *r*, the first leading to the gage in front of the pump, the other to the cock and receiver.

of one thousand times. By an account of Mr. *Corwall's*, in the 73d vol. of the Philosophical Transactions, I find an improvement made in Mr. *Smeaton's* pump, by Mr. *Haas*, instrument-maker. He has contrived to open the valve at the bottom of the barrel independent of the spring of the air underneath; and by this improvement he has increased the power of the pump to one thousand times. This experiment is a confirmation of what is to be expected from the removal of the valve in my pump, which is done with greater simplicity, as Mr. *Haas's* contrivance is complex, consisting of a ring lying at the bottom of the barrel, to which ring the valve is fastened; this ring is raised by a pedal, connected with two wires moving through two collars of leathers, and is depressed by a spiral spring contained in a socket, the whole being fixed under the barrel of the pump: But he has done nothing to remove the resistance from the valve in the piston, nor the weight of the atmosphere from off the valve on the top-plate.

The other barrel is left out of the figure, to show some of the parts more distinctly; except *Q Q* which is the top of the barrel retained and brought down out of its place, to show the top-plate, that shuts up the barrel, separated from the box, which contains the collar of leathers. *S* shows one of the holes in the plate over which the valve lies, and which is covered by *R* in the cross-piece. *V V* is the piston showing the valve open on the top, which is to prevent labour when the pump condenses. *W X* is the cistern, in which is more distinctly seen the shoulder for the leather which closes the joint between this and the barrel, and also the socket in which the oil lies over the leather. *Y Z* is the condensing gage, with the orifice of the tube raised above the surface of the quick-silver. *e e* is the collar of leathers, through which the glass tube moves. *i* is a small pipe coming up through the quick-silver to make a communication between the valves and the gage.

Fig. 4. is a view of the upper surface of the top-plate which closes the barrel, being folded into it, showing the place of the valve over the three small holes, one of which only can be seen at *S*, in fig. 3.

Plate V. fig. 1. is a perpendicular section of the bottom-piece, pipes, valve-pump, cock, &c. at right angles with the other section, fig. 3. pl. IV. *A B* is the pipe between the barrels, as represented in plate IV. The button *o* is here screwed into the top instead of the gage. *C D* is the valve-pump and its cistern, *e* the place of the valve under the cap. *E F* the cock, showing the duct through it leading to the atmosphere. *G H* the pipe leading from it to the stem of the receiver-plate, in which is the cock *I*, to shut up the duct when the plate is used as a transferer. *K K* is the plate. *L* a piece to shut up the
the

the hole into which tubes, &c. are occasionally screwed to perform experiments without removing the plate: the pricked line at O shows the place of the screw which presses the plate against the pipe: P Q the pipe and common gage standing in front of the pump.

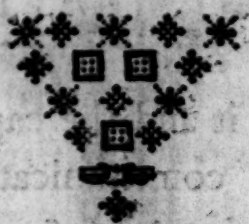
Fig. 2. is a horizontal section of the cock and pieces, containing the ducts leading from it to the receiver, the cisterns, and the valves on the top of the barrels. A B the duct connecting the cisterns together. C D the duct leading from the cisterns to the cock. G H the duct leading from the cock, through the pipe A B, (fig. 1.) to the valves. D E the duct through the cock, which occasionally connects the two last-mentioned ducts with the duct E F, leading from the cock to the receiver. I the duct in the cock leading to the atmosphere, which, when connected with the duct at D, lets the air into the cisterns and barrels for condensation; the other duct through the cock at the same time connecting H and E. This duct also, when connected with E, restores the equilibrium in the receiver. K L is part of the duct leading from the cisterns to the gage. The pricked circles show the places of the pipe and valve-pump on the piece, and r the place where the air enters the valve-pump from the duct G H, and is thrown into the atmosphere, when the pump exhausts.

Fig. 3. shows the under surface of the boxes, which contain the collars of leathers, with the cross-piece, which connects them together, having a duct through it, as represented by the pricked line, through which the air passes from the valves to the pipe: this fig. is designed chiefly to show the places in which the valves play, as at I.

Fig.

Fig. 4. is a side view of the pump, showing the situation of the valve-pump and handle of the cock; where A is the pump, and B the handle.

Fig. 5. is the top-plate which screws the key of the cock into its shell, and keeps it tight: the upper surface of it is marked with directions to turn the key so as to produce the effect desired: for when the mark on the key agrees with the mark on the plate, the pump exhausts, and so of the rest.



XXVII. *A Description of a Pump-Engine, or an Apparatus to be added to a common Pump, to answer the Purpose of a Fire-Engine; invented by Mr. BENJAMIN DEARBORNE: Extracted from his Letters to the Hon. JAMES BOWDOIN, Esq; President: communicated by the President.*

Portsmouth, November 5, 1781.

S I R,

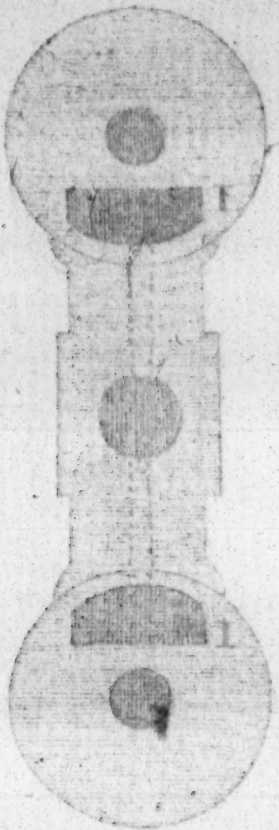
I HAVE spent some time in inventing the pump-engine, a model of which I have forwarded herewith. This engine is described as follows.

Plate VI. Fig. 3. A B C D represents a pump in the form of a common ship-pump. E its spout. F a stopper. D d is a plank cap, fitted with leather under it to the pump, and screwed down by the screws a b; having a hole in the center for the spear of the pump to pass through, round which a leather collar is made, as c. g is a nut for the screw b. f b is a square piece of wood, nailed across one end of the cap, the screw a passing through it and the cap; through this piece and the cap a hole is made, communicating with the bore of the pump. G G is a wooden tube (of any required length or number of joints) made square at the lower end, and hollowed to receive the cock, the upper end being made with a nice shoulder. e is a wooden cock, which opens or shuts the communication between the pump and the tube, having a handle on the opposite side, with a lock if necessary. b b are ferrules to prevent the tube from splitting. H H are braces, each of which must have another crossing it as nearly at right angles as may be. i i are irons in the form of a staple, going round the tube and through the braces, having holes in their ends for forelocks. K L M N is a head made of five pieces of wood, viz.

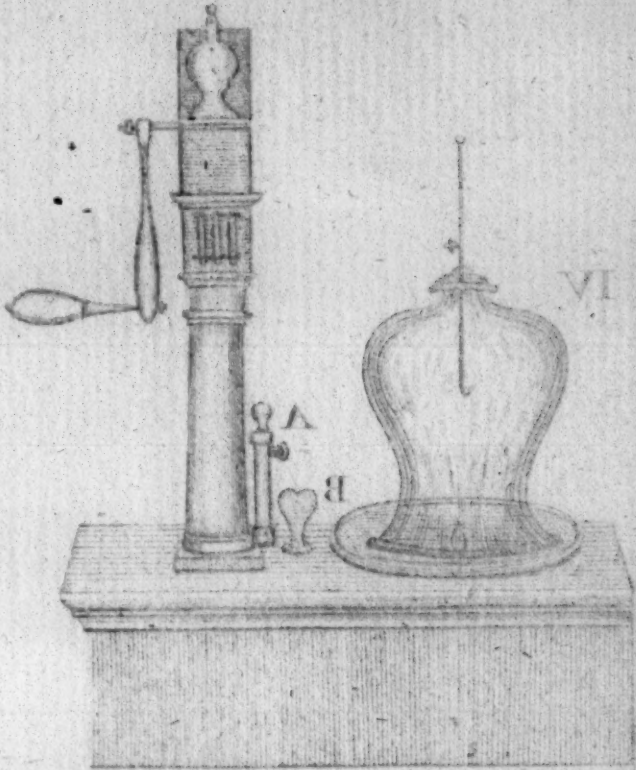
k l m n

III.

Fig. III

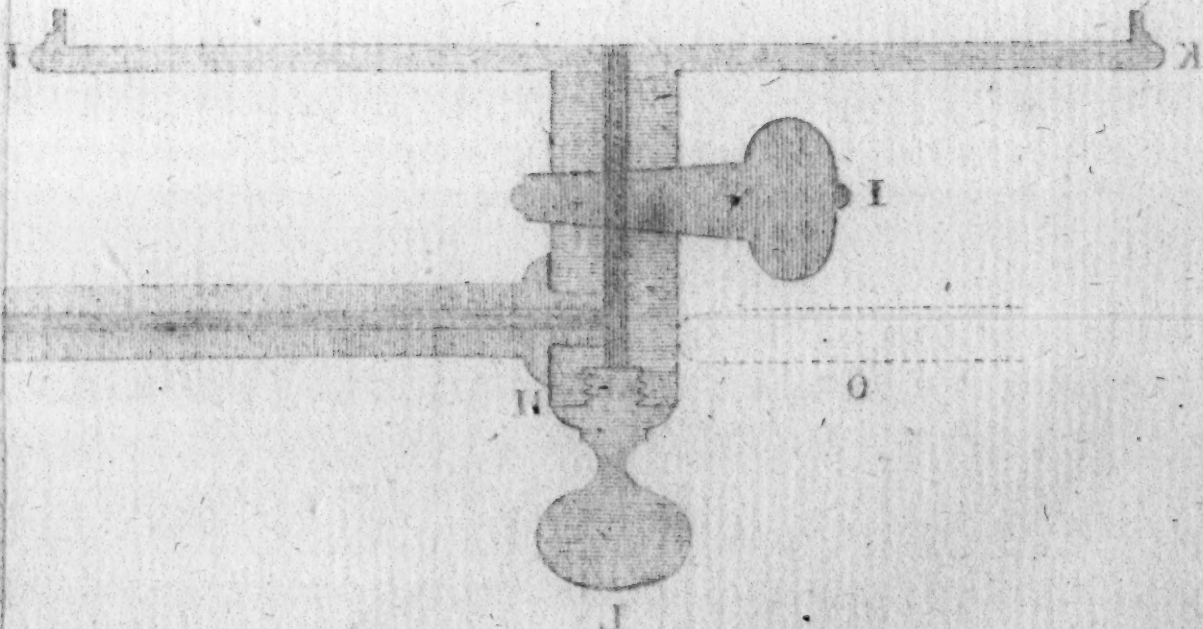
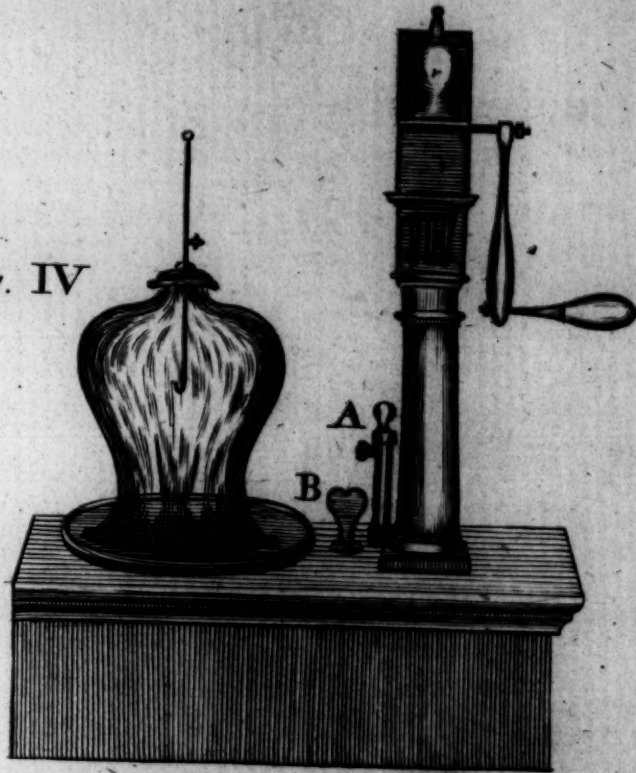


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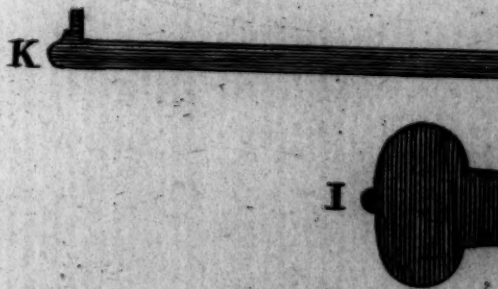


VI

Fig. IV



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0

Plate 5

AIR PUMP

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Fig. III

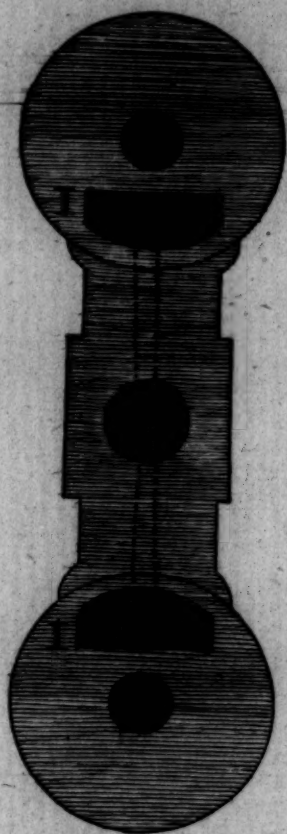


Fig. II

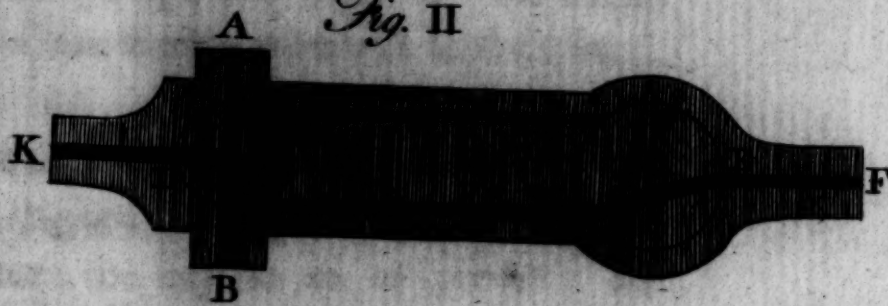


Fig. V

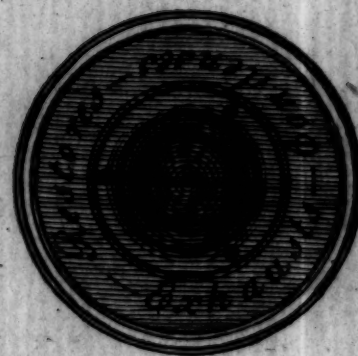
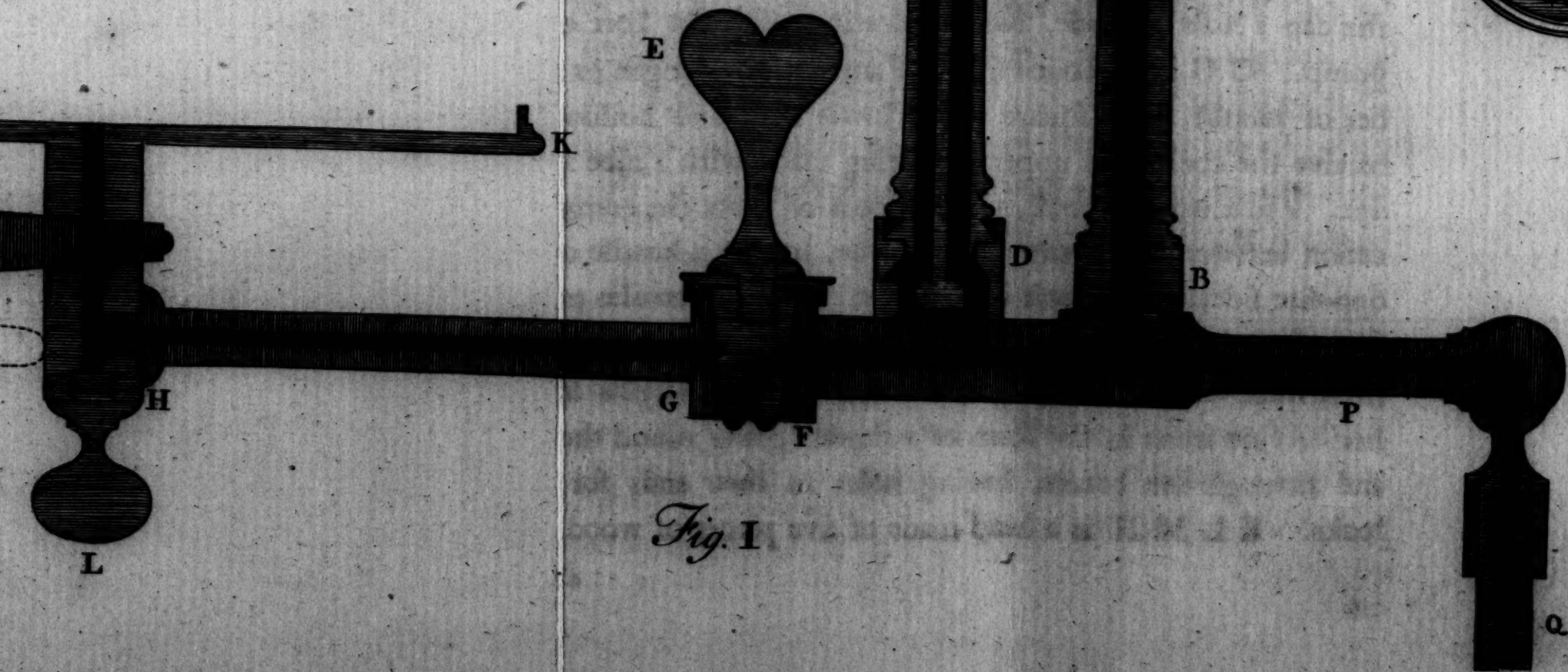


Fig. I



k l m n, a square piece, with a hole in the lower end, to receive the end of the tube, and rests on the shoulder *o p*; on the lower end of this head a leather is nailed, having a hole in its centre similar to the hole in the wood; another leather of the same form is put on the top of the tube, and a circle of thin plate-brass between them; the two leathers and the brass being pressed between the lower end of the head and the shoulder of the tube; their edges are represented by *o p*. *K N* and *L M* are the edges of two pieces of plank which are as wide as the head, and nailed fast to it, each of them having a tenon going through a mortice in the end of the piece *O P*; each tenon has a hole for a forelock at *q q*. *O P* is a piece of plank as wide as the sides, having a hole in its centre through which the tube passes, and a mortice on each end for the tenons to pass through. *N M* is a cap. *r r* are two pieces nailed on the side of the tube, with a truck in the lower end of each, to lessen the friction of the head in its horizontal revolution. *q q* are forelocks to wedge the head down, and prevent the water from finding a passage out at the joint *o p*. *Q R* is a wooden conductor; the end *Q* being solid, the end *R* bored with a small auger, *s* is a bolt going through the conductor and head, secured on the back with a forelock or nut; this bolt is round near the head and square in the middle. *t u w x* is a piece of iron or brass to prevent the head of the bolt from wearing into the wood. *S S* are ropes to direct the conductor.

Fig. 4. is the head without the conductor; *a b c d* is a thick brass plate perforated to prevent dirt from clogging the conductor, and nailed with leather under it to the head. The square hole in the centre is made to the size of the bolt, and prevents it from turning. The conductor has a hollow cut

S f f

round

round the bolt on the inside, as large as the circle of holes in the brass, round which hollow on the face of the conductor, a leather is nailed which plays on the margin of the brass plate, when the conductor turns.

I have raised a tube of 30 feet on my pump, but the severity of the season prevents my completing it; having so far executed it only, as for one person to work at the brake; I can myself throw water on the top of a neighbouring building, the nearest part of which is 37 feet from the pump, and between 30 and 40 feet high.



ropes to direct the conductor. Fig. 4. is the head without the conductor, a thick brass plate perforated to prevent dirt from closing the conductor, and nailed with leather under it to the head. The square hole in the centre is made to the size of the hole, and prevents it from running. The conductor has a hollow cut

round

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[523]

XXVIII. *A Description of a Fire-Engine of a new Construction, by the same. Extracted from a Letter to the same.*

Portsmouth, January 28, 1782.

S I R,

HAVING constructed a model of a portable fire-engine, on the same principles as the pump-engine, I do myself the honour to forward you a description of it.

Plate VI. Fig. 1. A B and C D are the edges of two planks, confined together by four bolts. *a b c d* are two cylindrical barrels: in each of these barrels a piston with a valve is fastened to the spear *e*, and is moved up and down alternately by the motion of the arms E E. Under each barrel a hole is made through the plank A B, and covered with a valve. E E are arms hung on the common centre *f*. Arms parallel to these are on the opposite side. *g* is the end of a handle which is fastened across the ends of the arms. A bolt at *h* goes across from arm to arm; to this bolt the piece *i k* is fastened, and plays upon it; the lower end of this piece is fastened to the top of the spear *e*. *G l f* is a standard to support the arms; another answering to it on the opposite side, both being notched into the edges of the planks, are sufficiently secured by one bolt going through them at *l*, and having a nut or forelock on the opposite side. H I H I are square braces, which answer the purpose of ducts, through which the water ascends from the barrels through the plank at *m*. K L K L are irons in the form of a staple to confine the braces; the lower ends of these irons meet, and are secured with one bolt going through them and M N *n o*, which is a piece going up through a mortice in the centre of the planks; this piece is square from the lower end upward as high as the top of the braces; from thence to the top it is cylindrical; the

S f f 2

upper

524 *A Description of Mr. DEARBORN'S Fire-Engine.*

upper end being bored hollow, far enough down to communicate with the braces. O P is an iron ring going round the tube, having two shanks going up through the head, with screws on the top at *p q*. *r s* is a ferrule nailed round the tube. The head and pipe are so nearly similar to those of the pump-engine that they need no further description.

Fig. 2. is the same engine; the arms and standards being taken off to give a more intelligible description of the mode of securing the braces, which is effectually done by one wedge driven into the mortice *a*, under the upper plank. *b* is a hole for the bolt to pass through which secures the standards. In this figure a side view of the head is given, with the pipe in a perpendicular direction.

The work is confined within a box set on wheels as common. The whole is made of wood except the spears of the pumps and a few bolts, &c. This model throws water about the same distance as the miniature pump-engine, the pumps being of the same bore. Engines on this construction may be made in any place where a common pump can; and the inside work will not be more than one quarter the cost of those on the usual construction; and the labour of working them will (as I conceive) be much less than in the others; these considerations may perhaps recommend them to some attention.



Plate 6

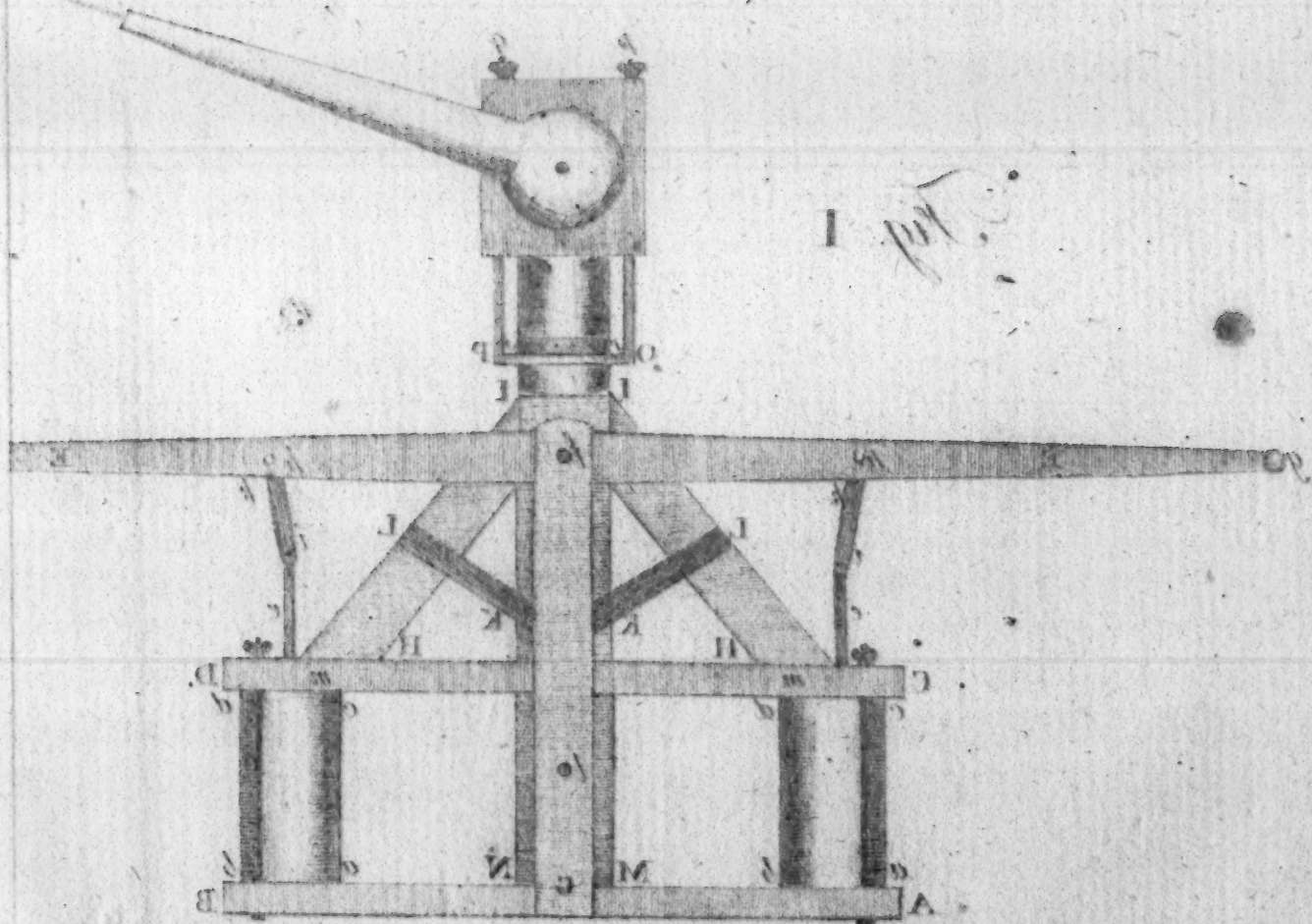


Fig. I

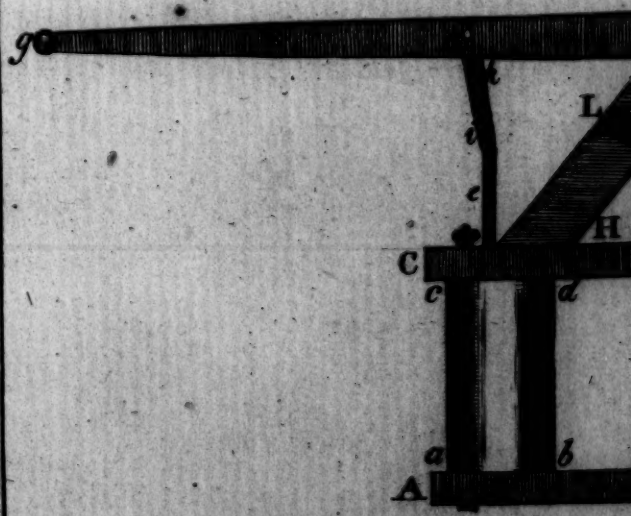


Plate 6.

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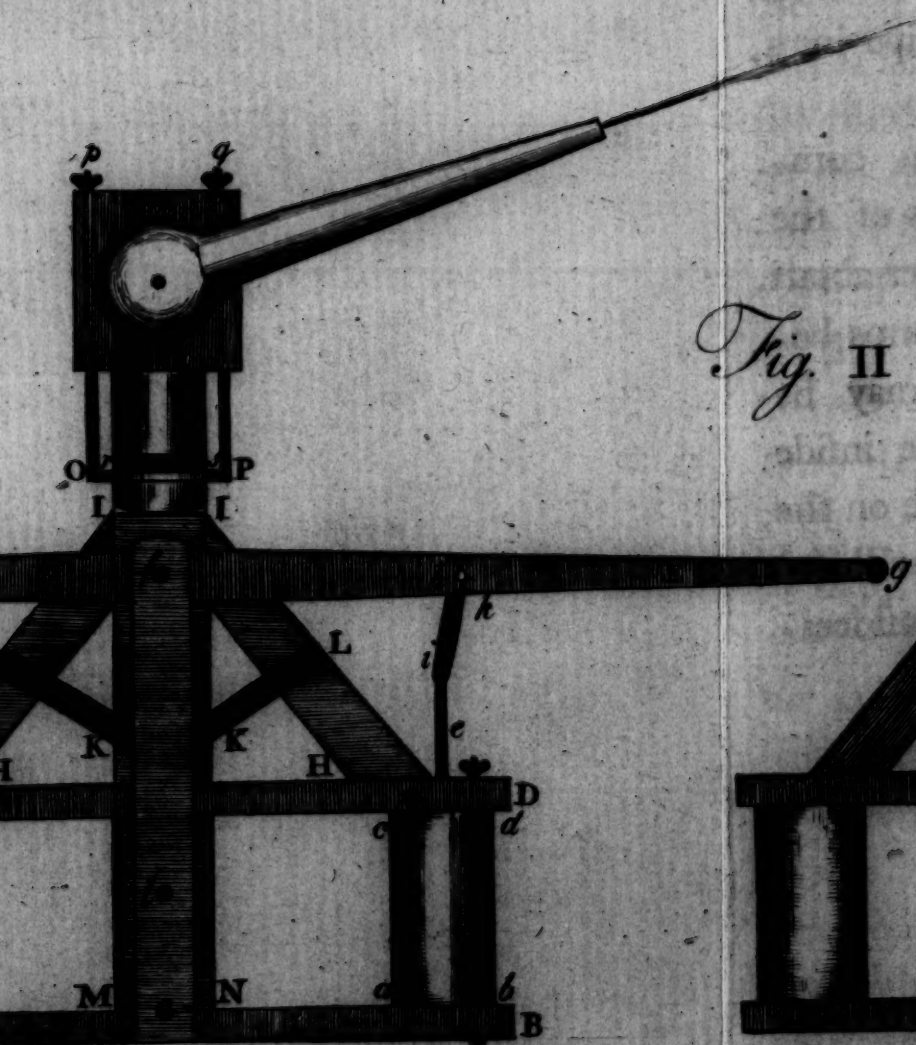


Fig. II

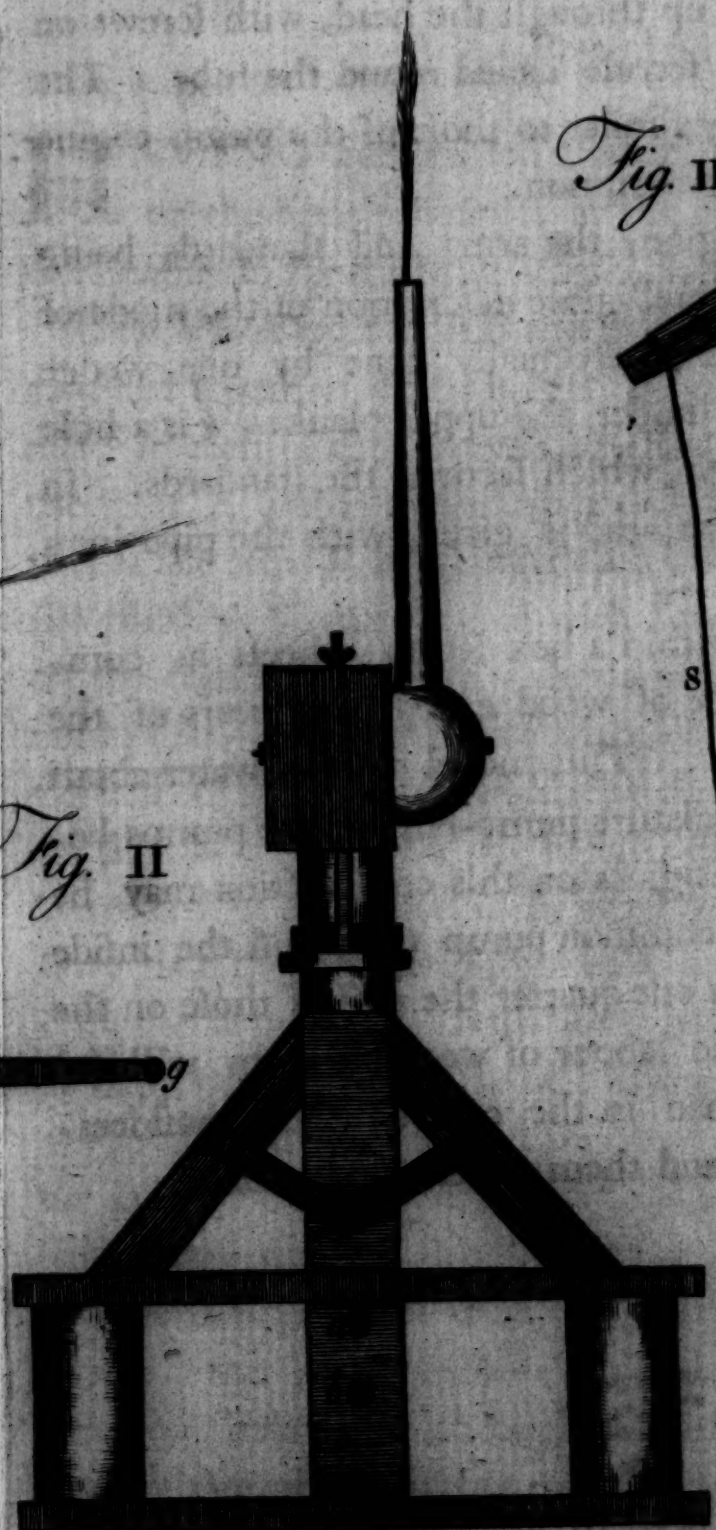


Fig. III

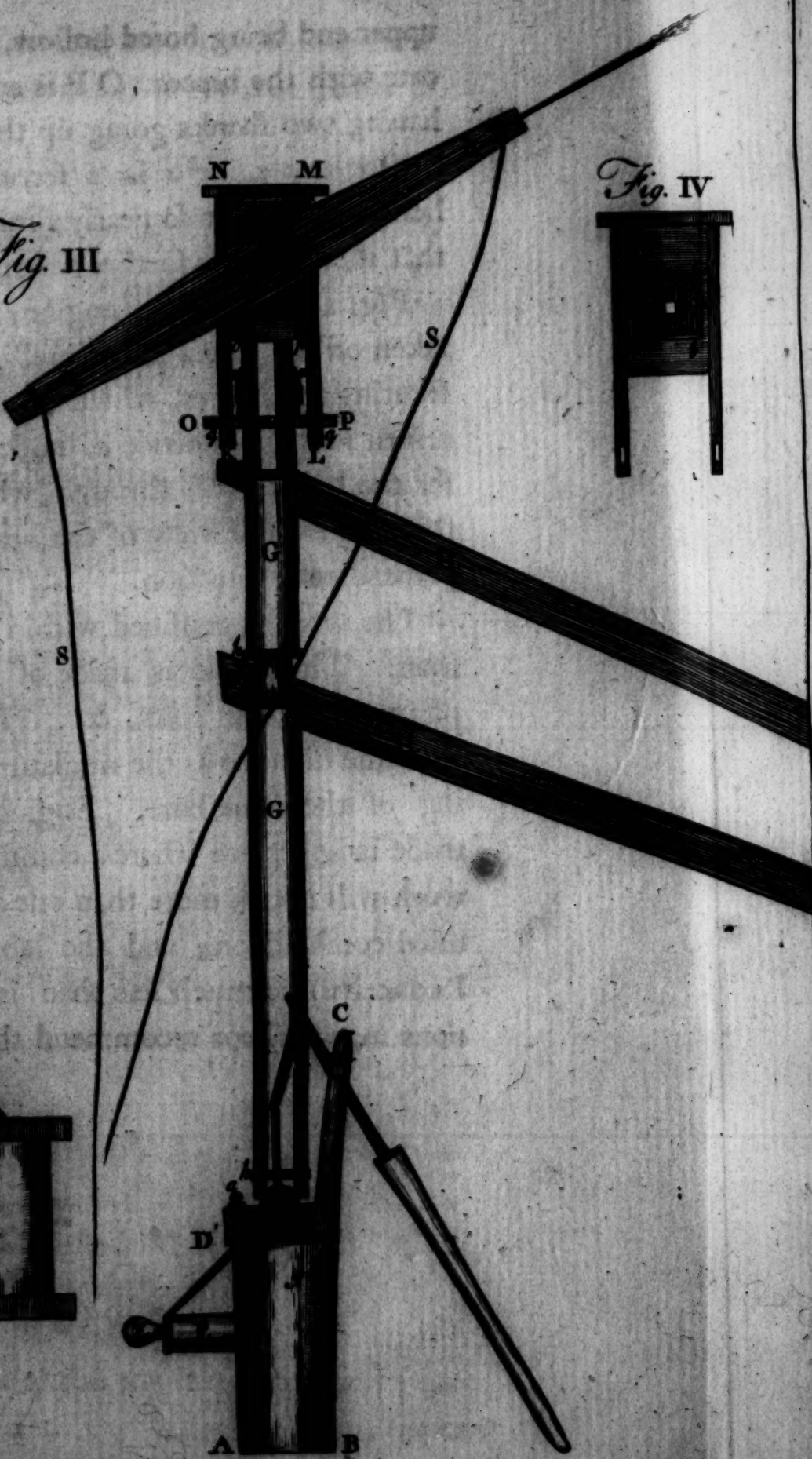


Fig. IV

XXIX. *Observations upon the Art of making Steel.* By the
Reverend DANIEL LITTLE, F. A. A.

AS steel is an article of commerce, and of great use both in the arts, manufactures and husbandry of every nation; and as we have the best of iron already manufactured in *America*, it is thought that the manufacturing of steel of a good quality, deserves the attention and encouragement of those who wish the welfare of the United States. What time I could redeem from other necessary business for several years past, has been employed in such disquisitions and experiments, as might tend to facilitate the art of making steel, and others near akin to it.

Those writers upon the subject which I have met with tell us, that the principal difference between iron and steel consists in this, That the latter is combined with a greater quantity of phlogiston than the former. Phlogiston exists in all inflammable substances, and in some that are not inflammable. Charcoal, and the coals of bones, horns and hoofs of animals, have been used as fit substances for communicating phlogiston to iron in making steel.

Steel is sometimes made by fusion of ore or pig-iron. The method is similar to that of reducing pig-iron to malleable iron, with this difference, that as steel requires more phlogiston than is necessary to iron, all the means must be made use of that are capable of introducing into the iron a great deal of phlogiston; that is, by keeping it, while in fusion, encompassed with an abundance of charcoal, &c.

The other method of making steel is by cementation, as it is called; that is, to convert bar-iron into steel; which is done by a cement made of those substances which contain the greatest quantity of phlogiston. Put the bar-iron with this cement in-

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to a vessel that will bear a strong fire; lute on a close cover, so as to prevent the cement taking flame and consuming; put the vessel in a furnace where the bars may be kept red-hot till they are converted into steel, which will be in a longer or shorter time, according to the bigness of the bars, and the quantity of cement.

This latter method has chiefly engaged my attention, which method is pretty well known in some parts of *America*, and, for many years past, steel has been made by it in several of the United States. Yet, so far as I have been informed, it has generally been of an inferior quality, and very little used for edge tools, which I supposed could not arise from the quality of the iron, for we have the greatest variety, and the best sort, in many parts of the country. I then conjectured there might be found some other inflammable substance for a cement, which, if properly applied, would impregnate the iron with phlogiston more advantageously. And, after many experiments, I found a particular marine plant that requires no other preparation but drying and pulverizing, and is commonly known by the name of rock-weed, or rock-ware, and is in the greatest plenty on our rocky shores, coves, creeks and harbours of the sea. In making some experiments upon this plant for a flux powder, a small bit of iron was put into a crucible, and filled with the said cement; and, very unexpectedly, after it had been in a little more than a cherry heat for five or six hours, it was converted into steel, which gave me the first hint of its use in making steel; since which I have had repeated experience of its excellency for the same purpose.

It needs no other preparation than to be cut off from the rocks with a scythe or sickle, spread on the dry land till the rains have washed

washed off the greater part of the sea-salt, then dried and pulverized, then used as other cements are in making steel: or, instead of washing off the sea-salt, it is better for some particular kinds of iron, to neutralize it by adding a fixed alkali.

To two parts of the plant well dried and pulverized, add one part of good wood-ashes; mix together and moisten the whole with water or rather urine to the consistence of a very thick paste.

It is well known that in every new art, and in perfecting old ones, many unforeseen difficulties arise, and sometimes considerable fortunes have been spent before the manufacturer or the public have been much benefited. And since honest, but too credulous minds are often deceived by uncertain proof, and being willing to satisfy myself and others, by a better testimony than my own, I engaged a * gentleman of ability in the steel way for many years, whose furnace was complete and large, to make experiments upon my new discovered substance for a cement, who has written me, that "this steel is preferable to any he had ever made before." After all, I suppose different modes of preparation and further experiments will more fully ascertain its utility.

The matter of the furnace must be of such substances as will endure a strong fire without fusion. Asbestos has been used to advantage, but a sufficiency of it is not found in many places. Pipe-clay with one third part of pond-sand, or, which is better, white stones free from grit, well burnt, and pulverized, instead of sand, some species of slate and tale may be used with pipe-clay for furnaces and crucibles.

The chest or interior part of the furnace, for depositing the cement and bars of iron, must be covered so close that the inflammable substance within may not be consumed, but changed

like

* Col, Eliot of Connecticut.

like wood in a coal-kiln. The iron to be chosen of the best quality; its toughness and malleability are marks of choice.

Of the ore of iron.—This is often discovered by the magnet, but a great part of the best ore is that which the magnet will not attract, as *Linnaeus* and *Macquer* justly observe. When in that state it often resembles the rust or calx of iron. Many tuns of which are brought to the iron-works in this neighbourhood, from which the best of iron is made. In its natural state the best magnetic bar will not attract the smallest particle; but when roasted with charcoal it becomes magnetic. This method of knowing whether any earth or stones contain the true ore of iron, may be of use to discover new bodies or beds of ore. The reduction of metals, or restoring them to their metallic state from their calces, by combining them with the inflammable principle in the application of charcoal, may sufficiently show the efficacy of the above method for the discovery of the earth of iron in those substances on which the magnet has no effect.



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PART III.
MEDICAL PAPERS.

- I. *An Account of the Horn-Distemper in Cattle, with Observations on that Disease.* By the Hon. COTTON TUFTS, M.D. F.A.A. and M.S. In a letter to the Rev. JOSEPH WILLARD, Cor. Sec. A.A.

BEASTS of the forest, guided by the dictates of nature, and uncontrouled by man in their food, air, exercise and rest, are seldom affected with any disease, whilst in almost all countries, the domestic kind, that are more immediately under the government of man, are subject to a variety.

Scarcely an instance in this country of reigning sickness among tame or wild beasts, has been noted by its historians; and it is within thirty years that we have heard much of epidemic diseases among either.

About twenty-five years past an epidemic distemper prevailed among dogs, and occasioned a great mortality. In 1768 horses were generally affected with a disorder of the head and throat, which proved fatal to many, and much injured the serviceableness of those that survived. About the year 1770, there were some instances of the *rabies canina*; happily but few dogs were affected, and but few persons were bit; their rage principally fell upon swine. In 1771, a mortal distemper prevailed among foxes, and greatly reduced their numbers: about this

T t t

time

time, or not long after, a distemper appeared among neat cattle, which destroyed many, and has continued to this day. The distempers that beset these several kinds of animals, were said not to have been known in the country before, more especially that which has affected neat cattle, and which has generally been considered as a new disease: Some, however, have supposed it to be the same, which from time to time has made ravages in *Europe*, and more especially in *England*. Whether it was ever known there is uncertain. It evidently differs from those which *English* writers have mentioned as proving fatal to their cattle. The compilers of the complete body of husbandry, republished in 1768, make no mention of this disorder, though they have treated largely of the disorders of horn-cattle, those that have been more especially prevalent; and have proved mortal, they have described under the names of *gargil*, *garget* and *murrain*, and as attended with external swellings, inflammations, eruptions, and contagion, and add, that "the *murrain* is the distemper now, and of many late years, so fatal among the horn-cattle." In 1757, *Daniel Peter Layard*, M. D. F. R. S. published a particular account of the nature, causes and cure of the distemper then among the horn-cattle in *England*. He considers it as an eruptive disease, in the several stages, progress and effects of it, exactly the same with the small-pox, and earnestly recommends inoculation. None of the external swellings, eruptions or contagion, characteristic of these disorders, and to which swine and sheep, as well as neat cattle of all ages and kinds, are incident, are peculiar to this disorder. It is commonly called the horn-distemper: Cows are more especially subject to it; oxen but seldom,—bulls are said to be exempt from it, also steers and heifers under three years of age. It is a disease that affects

affects the internal substance of the horn, commonly called the pith, insensibly wastes it, and leaves the horn hollow. The pith is a spongy bone, whose cells are filled with an unctuous matter; it is furnished with a great number of small blood vessels, is overspread with a thin membrane, and appears to be united by suture to the bones of the head, and is projected to a point. In a healthy beast it fills up the cavity of the horn, the horn itself being a sheath or case giving firmness, and the whole serving as a weapon of defence.

This spongy bone, in the horn distemper, is sometimes partly and sometimes entirely wasted. The horn looses its natural heat, and a degree of coldness is evident upon handling it; when it is only in one horn, (which is often the case) a manifest difference between the one and the other will be perceived, and in all cases a want of natural heat will be apparent; wherever this is found, there is no room to doubt of the disorder's being present; yet it is seldom suspected without a particular acquaintance with other symptoms that commonly attend this distemper, and for want of knowing these, the farmer has often lost his cattle, not even suspecting the evil.

These symptoms are a dulness in the countenance of the beast, a sluggishness in moving, a heaviness of the eyes, a failure of appetite, an inclination to lay down, an aversion to rise, and, when accompanied with an inflammation of the brain, a giddiness and frequent tossing of the head; besides these the limbs are sometimes affected with stiffness like a rheumatism, and in cows the milk often fails, the udder is hard, and in almost all cases there is a sudden wasting of the flesh.

As soon as the disorder is discovered, an opening into the diseased horn should be immediately made, which may be done

with a twenty-penny-nail gimblet, in a part of the horn which might be supposed to be most favourable for a discharge; it is most prudent to bore, at first, two or three inches above the head; if it is found hollow, and the gimblet passes through to the opposite side without resistance, and no blood discharges from the aperture, it may be best to bore still lower, and as near the head as it shall be judged that the hollowness extends. This opening is a necessary measure, and often gives immediate relief. Care must be taken to keep it clear, as it is apt to be clogged by a thin fluid that gradually ouzes out and fills up the passage. Some have practised sawing off the horn, but from the best observations it does not succeed better than boring.

In autumn, 1774, on a farm not far from my house, I had four cows seized with this distemper in the space of a fortnight, the first, an old cow, was affected with stiffness in her hind parts, her milk failed, her udder was hard and swelled, her eyes heavy, and her flesh suddenly wasted. My tenant requested me to view her, upon an apprehension that she had met with some hurt. At this time the disorder was not much known among us; fortunately a person fell in my way who had seen a similar instance, and upon relating the case, he suggested that it was the horn distemper, and upon examining her horns, one of them was found to be cold, and was immediately bored with a gimblet, which passed through to the opposite side without resistance, and no discharge followed; finding the horn hollow, I was led to think that the bones below were carious, and immediately made a mixture of rum and honey, with the addition of some tincture of myrrh and aloes, and syringed the horn; the injected liquor was soon discharged at her nose, tinged with blood; this was repeated several times, daily, and the injected
liquor

liquor continued to run off through the nose for two or three days; at length it ceased to pass that way.—Emollient fomentations were applied to her bag—these were the only applications.—The cow in a few days shewed signs of recovery, but did not regain her flesh for several months. A second and third cow were taken ill; the disorder being early discovered, their horns bored and syrringed several times, they soon recovered. A fourth cow, about four years old, was observed, in the morning, to have the disorder, her horns were bored and syrringed, her tail* cut for the purpose of bleeding, and from suspicion of defect in it; by nine o'clock she was scarce able to stand, at noon she was unable to rise, her head was very hot, her eyes dull, and she groaned as if in great pain; towards night she appeared as if near expiring, her eyes were unmoved at being touched, and the lustre of them entirely gone, some degree of coldness, and a universal convulsion attended her; under these circumstances, I directed my tenant to take one ounce of powdered mustard-seed, to simmer it in a quart of milk, and add thereto one gill of molasses, the whole to be given immediately, afterwards to cover her over thick with straw,—this was soon done. In this state she was left in the evening; before morning she had escaped from her straw, and was feeding in the field. She recovered without any further application.

In the spring of 1779, another cow, of four years old, was seized; she was observed in the morning to refuse her food, her eyes were heavy, she hung down her head and manifested an unhealthy countenance; the disorder was suspected, her horns examined;

*Of Neat cattle are subject to a disorder commonly called the tail sickness, which is a wasting of the bony substance of the tail, and if not cut off or dilated as far as the defect reaches, often proves fatal. It frequently accompanies the horn distemper.

amited; one of them felt cold, was bored, found hollow, and syringed; through the day she was giddy, tossing her head backward and forward, frequently groaned as if in great pain, and upon rubbing her forehead shewed signs of ease, her strength was not much diminished, her natural evacuations by stool and urine were free; however, she died the next morning; and, according to the information of my tenant, upon opening the body, the *viscera* were all sound, no mark of disorder was seen there; but upon opening her head, the brains appeared of an unnatural colour, and, by his account, tending to a mortification.

From the number of cows seized with this distemper in the space of a fortnight, as before mentioned, a suspicion arose that the distemper was infectious; time, however, has shewn that it is not so, at least in any great degree, for it frequently happens, that among many cattle herding together, one of them shall have the distemper and the other remain in perfect health.

It appears from the first recited case, that the injected liquor had a free passage from the horn to the nose; yet, previous to the boring of the horn, there was no visible discharge at the nose of the wasted substance, or of any other matter, nor has there been in any other instance that I have heard of. As there appears no external discharge of the wasted bone, it must probably lodge in the cavities of the head, and, in process of time, affect the brain; or the matter may be subtilized to a great degree, and be drawn into the circulations. It seems surprising that so large a portion of bone as that which fills up the horn should be destroyed, and the beast manifest no more complaints than are commonly observed; for the whole substance is generally lost, before the complaints rise so high as to excite the notice of the farmer. To account for this, may it not be supposed,

posed, that the mortification or dissolution of the pith is attended with a degree of insensibility, and that the distress discovered does not exist in any great degree until the brain is in some measure affected, or the matter is absorbed, and injures the habit in general?

Air-bubbles are continually forming at the orifice, through which the thin fluid ouzes after the horn is bored. This indicates an internal fermentation, and it is not improbable that putrid matter of some kind or other may have given rise to it. The matter may at first be formed on the periosteum, and entering into the interstices of the bone, may dissolve the oily substance, and form a fluid so putrid and corrosive as to dissolve even the bone itself; upon this supposition, the air within becoming putrid and confined by the heat of the parts, will be largely expanded, from whence a great degree of compression upon the surrounding parts must ensue; its effects at first may be small, after a while greater; at first producing no great distress, after a while some pain, but not sufficient to produce such uneasy sensations as to be noticed; but when the bone is entirely wasted and the putrid air much increased, and the compression become great, the tender vessels of the head must feel the force of it; the humors also may be highly acrimonious, and produce a general irritation. But from that sensible relief that an opening into the horn gives the beast, it is more than probable that the distress discovered arises from compression, rather than from an effect produced on the blood and juices; for, in some instances, the beast is almost instantly relieved by making an opening into the horn.

The passing of liquors from the horn to the nose, as in the case first mentioned, may perhaps be considered as an objection
against

against the compression supposed; but it is to be noted, that though there was a communication between the horn and the nose in this case, yet it does not appear that there was any in divers other instances, and in this also after several days.

From late observations I am led to conclude, that injections are in general unnecessary; that when the distemper is early discovered, no more is required than a proper opening into the horn, keeping it sufficiently clear for the admission of fresh air, the removal of the compression, and the discharge of floating matter. But when the distemper has communicated its effects to the brain, so as to produce a high degree of inflammation, it is much to be doubted whether any method will succeed.



II. *Case of a remarkably large Tumour, found in the Cavity of the Abdomen.* By JOSHUA FISHER, F.A.A. and M.S.

THE subject of the following memoir, was a woman of strong habit, rather spare than gross, and of an active disposition. She lived in a married state from early life, but never had a child; was not peculiarly subject to any disorder, except some florid cutaneous eruptions, till at about the usual time of life the *catamenia* ceased. Soon after that period she became sensible of an unusual fullness in the abdomen, which continued almost imperceptibly increasing, without any disagreeable symptoms, till she was near sixty years old, about two years before her death. She then complained of a pain in the left hypochondriac region, which became sensibly tumefied; the pain and distension from thence increased, and spread over the whole abdomen.

I first saw her between four and five months before her death; I found the abdomen very large and tense, especially on the left side, which was the most painful: the vessels in her head and arms, were full and turgid, while an inanition had taken place in the lower extremities, with a variety of symptoms arising from an unequal distribution of the circulating fluids and nervous influence. But the immediate cause of her principal complaints was an inflammation, which appeared to be seated forward of the *rectum*; although scarcely any part of the abdomen was exempt from attacks of the most excruciating pain at intervals, yet the lower and posterior parts were principally affected; and while a suppuration was forming (which had probably taken place several times before I saw her) the pain darted a little backward and downward, and terminated in the

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rectum,

rectum, by which a quantity of bloody pus was, at length, discharged. Her bowels were generally constipated, and when the symptoms were the most severe, the discharge of urine was small, and attended with pain.

The principal medicines that I made use of, were *haust. salin.* *Ol: Ricin:* with *anodynes p. r. n.* In the space of a few weeks, the symptoms of inflammation disappeared, the secretions and excretions became free, and by the use of the bark and gentle exercise, she recovered a considerable degree of strength, the symptoms arising merely from distension and compression being very tolerable. This truce lasted about two months: a sudden suppression of perspiration was followed by a return of her complaints with redoubled violence, and some paralytic symptoms. On the twelfth day of her relapse, she discharged a considerable quantity of purulent matter, intermixed with some blood and fœces, but without any relief, and she died on the fourteenth. In her last struggles, which were very violent, she discharged (probably *per vaginam*) a quantity of darkish water, resembling high-colour'd urine, amounting, by estimation, to at least two gallons. This discharge considerably reduced the bulk of the abdomen, especially of the left side.

The day after her death, I went about noon, with the Rev. Mr. Cutler, of *Ipswich*, and Dr. Spafford, of *Beverly*, to open the body. We expected that it would not be buried till the day following, but to our great disappointment, found it was to be interred the same afternoon: at length, however, we were allowed an hour to examine it.

On opening the abdomen, which now appeared about as large as in the last month of pregnancy, a preternatural substance presented itself, situate a little more to the right side than to the
the

the left, and occupying nearly the whole cavity. After separating it from the contiguous parts, to all of which it firmly adhered, its general figure appeared to be that of a cone or pear; the lower part (supposing the body erect) being within the *pelvis*, was very nearly conical; the upper part was divided by two grooves, running in a right line from its basis, towards the apex; the one on its anterior, the other on its posterior side, dividing it into two lateral portions, and giving it the appearance of its having been formed by two globular bodies, compressed together. The posterior groove corresponded to the projection of the spine, to which it adhered; the anterior groove was wider, and the protuberances on each side somewhat larger. The basis lay above the kidneys, and the apex nearly low enough to form a tumour in *perinaeo*: By cutting into it, it appeared to be an uniform schirrus of a cineritious colour, with vessels, or rather perforations interspersed, for conveying the circulating fluids. From its situation, connections and figure, it appeared to have originated in both the *ovaria*; the two schirrosities in process of time united, and meeting with the least resistance from below, extended into the *pelvis* till the cavity was completely filled. It weighed upwards of ten pounds and a quarter, averdepois weight. We made some observations on the neighbouring viscera, but for want of time, they were unavoidably very imperfect.

The *vesica urinaria* was moderately distended with urine, forming a tumour over the *ossa pubis*, the neck being compressed between the *pubis* and the schirrus; its whole anterior surface was firmly attached to the *peritoneum*, and the posterior to the schirrus, except a small portion in the middle of it, which adhered to the *uterus*, where that viscus intervened. The ure-

ters, for the space of two or three inches, seemed to lie loose, and contained a small quantity of urine; their coats were thin and considerably distended. They then entered upon the schirrus, one on each side, involved in a membrane hereafter mentioned; running obliquely forward and downward, till they entered the bladder; after they were connected to the schirrus, their appearance was the reverse of the former: to enable them to take this circuit, they had been greatly extended, and their diameters were exceedingly small. The *uterus* was extended in a right line upon the schirrus from its basis, to which the *fundus uteri* adhered, through the anterior groove, almost to its apex, continuing about an inch and a quarter wide, and firmly attached through its whole length. Its coats appeared in a natural state, except that they were thinner by reason of their extension.

The appearance of the *tubæ fallopianæ* was so unnatural that they were scarcely distinguishable; we found a membranous covering closely embracing the basis, the anterior, and lateral sides of the schirrus, extending downward nearly to the *pelvis*; and by its upper and lateral edges adhering to the schirrus, it seemed to arise from the *uterus*, which was situated in the middle of it, and its external membrane was a continuation of the external membrane of the *uterus*. Through this expansion on the basis of the schirrus were several smooth but irregular apertures, of about two inches circumference, through which the basis of the schirrus appeared; it was here about a quarter of an inch thick, its fibres fleshy and variously convolved, the lower part of it was much thinner and purely membranous. That part of this tegument which was spread upon and near the basis, appeared to be formed by a distension of the fallopian tubes included in the
- *peritoneum*

peritoneum or common membrane of the abdomen, and the remainder of it by an expansion of those duplicatures of the same membrane, usually termed *ligamenta lata*.

On the backside, the schirrus was attached to the *aorta*, *vena cava*, &c.—to the *rectum*, which was protruded to the right side of the spine, it adhered for the space of seven or eight inches : Near the basis, the adhesion was strong ; but a little lower, the connecting membrane contained a quantity of grumous blood, appeared putrid, and in some places was destroyed.

We wished to have ascertained the source of the water which the patient discharged at the time of her death : by the appearance of the viscera there had been none diffused in the cavity of the abdomen ; and, from the circumstances above mentioned, it must have been contained in the left *hypocondrium* : In removing the schirrus, we found a membrane (a sac to appearance) adhering to it, which we cut through, and supposed to be an empty hydropic cyst ; but the schirrus at that instant engrossed our attention ; and people soon collecting to attend the funeral, all further examination was prevented.

We observed nothing extraordinary in any of the other viscera ; the *omentum*, as is usual in tabid cases, was nearly wasted, and a number of the mesenteric glands were enlarged and indurated.

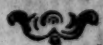


III. *Remarks on the Effects of stagnant Air.* By EBENEZER BEARDSLEY, Surgeon of the 22d Regiment of the American Army, in the Campaign of 1776.

ABOUT the beginning of April, 1776, the *American* army, under the command of his Excellency General *Washington*, marched from *Boston* for *New-York*, at which place they arrived near the middle of the month. The sick and invalids having been left behind, the whole army were in perfect health. They took up their quarters in the barracks and houses of the citizens, 'till about the first of May, when they all went into tents, except the 22d regiment, under the command of Colonel *Samuel Wylls*, who, for want of tents, continued in their quarters in *Smith-Street*. This regiment was very healthy until about the middle of the month, when upwards of one hundred of the men were taken down with the dysentery in the space of one week. Such a sudden invasion of this formidable disease alarmed me greatly. As I found upon enquiry that there was not a single dysenteric patient besides, in the whole army, I concluded that the disease arose from some cause peculiar to the city: but after a careful enquiry, I could not find that there was a single inhabitant in the whole city that was sick with the distemper. Those who lived in the same street, and many of them in the same houses with us, were entirely free from this, or indeed any other disease. For several days I was much perplexed, and greatly at a loss as to the cause. At length I observed that not only the citizens with whom we lived were free from the disease, but that some whole companies of the same regiment had nothing of it. This led me to consider more minutely the situation and circumstances of those who were sick; all of whom, I found, lived either in
low

low underground rooms, or else in garrets, so situated as not to admit of a free circulation of air. The rooms were also considerably less in proportion to the number of men than usual. Struck with these discoveries, I concluded at once, that the disease arose from a confined stagnant air; deprived by this means of its natural elasticity, and loaded with putrid *effluvia* from the bodies of the unhappy people who lived in it. Having communicated my discoveries to the Colonel, I requested that the men, (both sick and well) might be removed out of those rooms into such as were more airy and capacious. This measure was attended with the most salutary consequences. Those who were sick recovered in a short time, except one or two that died; and no more being seized with the disease, in a few weeks the regiment became entirely healthy. There was nothing peculiar in the symptoms which attended the disease, except, as is usual in vernal distempers, that there was a greater degree of inflammation than commonly attends autumnal disorders of the same *genus*. The discovery of this singular instance of the pernicious effects of confined stagnant air, was of great use to me in the course of the campaign. In the months of July and August, the dysentery, bilious and other fevers of the putrid kind, became very rife both in the army and country. Great pains were taken to procure for our men who were sick with any of those disorders, large rooms, and to have them well ventilated. Yet, under these circumstances, I frequently observed, that (*ceteris paribus*) the sick who lay in and near the corners of the rooms, were handled much more severely than those which lay in the middle of them.

I do not remember to have met with this observation before, but it is undoubtedly of great importance in the treatment of dysenteries and other putrid diseases.



IV. *A remarkable Case of Gun Shot Wound. Communicatd in a Letter from BARNABAS BINNEY, Hospital Physician, and Surgeon in the American Army, in 1782, to the Honorable BENJAMIN LINCOLN, Esq; F. A. A.*

ON April 9, 1782, *David Beveridge*, a seaman, belonging to the sloop of war *General Monk*, was brought into the military hospital at this place, having been wounded the day before. He was a lad of about nineteen years of age, and in a good state of health, at the time of the action between the said ship and the *Hyder-Ally*. In that action he was in the main-top of the *Monk*, when he received a musket-ball in his belly from one of the marines on the quarter-deck of the *Hyder-Ally*, then within fifteen yards of the *Monk*. The ball entered his belly about two inches above his left groin, and within an inch of the anterior edge of the left *ilium*, passing out two inches on the right of the spine between the two inferior true ribs, just touching the cartilage of the inferior angle of the right *scapula*. When he came into the hospital he had bled much, was very weak and cold, had a faltering voice, a cadaverous countenance, and a constant hiccup, while his *fæces* passed freely out of the wound in his belly. In this deplorable condition, where neither art nor nature could promise any permanent relief, the only dictate of humanity was to smooth the path of death. Being also in great pain, I advised him to take a glass of *Madeira* wine, with twenty or thirty drops of *liquid. laudan.* in it, as often as necessary. He accordingly began, and continued this practice 'till the thirteenth, finding constant relief from it. He took no kind of sustenance all this time excepting wine whey, never having any kind of discharge *ab ano* from the moment he was wounded, but constantly squirting with considerable force what

what fœces he had, through the wound in his belly. On the fourteenth he had a common glyster administered, the greatest part of which also came out at the wound, the remainder coming as it went, *ab ano*, without bringing any fœces. From the fourteenth to the eighteenth he took considerable quantities of gruel and whey, with a little wine occasionally, having no intestinal discharge whatever but what was made through the wound in his belly. On the eighteenth, as his strength was much increased, and as the wounds were considerably contracted, and looked well, I ordered another injection to be administered gently, when, for the first time, in eleven days he had a natural stool. From this time he had no further discharge of fœces through his wound; his excretions became as regular and as natural as ever they were; his wounds suppurated and healed kindly; his strength returned; and he was exchanged nearly as well as ever, on the thirtieth.

That the ball had passed through the colon is obvious, from the discharge of perfect fœces and of the injection administered, *ab ano*. That his life depended upon our not meddling with the wound, and upon keeping him quiet and easy, is also plain; as the least removal of the orifice in the intestine from the orifice through the abdomen, which were so happily opposed to each other, must have been attended with a fatal discharge of the fœces into the abdomen. That the diaphragm and lungs were perforated is plain, from the course of the ball, and his profuse hæmoptoe. That Surgeons may be too officious, as well as too tardy; and that where they are not certain of the utility of their operations, they had better leave even the most desperate disorders to the management of nature, ever provident, and generally adequate, are points remarkably enforced in this particular case.

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V. *A Bill of Mortality for the Town of Salem, for the Year 1782.* By EDWARD AUGUSTUS HOLYOKE, M. D. F. A. A. and M. S. In a Letter to Mr. CALEB GANNETT, Rec. Sec. A. A.

S I R,

I Herewith send you a bill of mortality, for the town of Salem, for the last year, which, although not so accurate as I could wish, may yet perhaps be worth communicating to the Academy; heartily wishing the public might be favoured with more correct bills of a like kind, from a variety of towns, of similar, and of different situations, for a course of years successively, as they would certainly afford the best means of judging of the state of population, a matter of real use and of great curiosity.

Salem is a sea-port town, situated in the 42d degree of N. Lat. on *Massachusetts-Bay*, about five leagues to the westward of *Cape-Ann*, and about as far north-eastward from *Boston*; where a considerable trade is carried on both with *Europe* and the *West-Indies*. That part of it which is settled thickest, is mostly a peninsula lying between two salt water rivers. The ground is flat and low, being scarcely more than twenty, or twenty-four feet above the level of the sea, at high water, any where, and in most places not near so much; and excepting a hill in the north-west, and another to the westward, neither of them very high, there are no eminences to interrupt the free course of the winds. The soil is in general light, dry and sandy, and quite free from any marshes or collections of stagnant waters. The water of the wells, which are very numerous, is pretty good, that of many so pure as to bear soap well; though, I think, our tea-kettles are generally covered on the inside with a stony crust.

The

The inhabitants are not subject to any endemic disorders, though, thirty or forty years ago, hysteric and nervous complaints, are reputed to have been more than commonly rife here; at present, I believe we are as exempt from such maladies as the neighbouring towns.

In the following bill the number of the *dead*, I believe, is pretty accurate; the *ages* of the deceased in general, and the *month* they died in, are tolerably ascertained; but as to the list of *diseases*, I cannot be answerable for a considerable part of it, as the best account I could procure of the disease is sometimes taken from the sextons, the reports of nurses or persons about the sick; and how uncertain *that* must be, I need not say, when even physicians themselves are often at a loss how to class the diseases of their patients, with the precision they would wish; and in several instances I have not been able to procure any account of the disease at all: I thought it better, however, to give a bill of that sort, imperfect as it is, than to suppress it entirely. As to the *births*, I believe the account is as compleat as can be expected, considering from whom we are obliged to collect the greatest part of it; and, I suppose, approaches much nearer to the number of persons actually born, than accounts of christenings ever can, in any country where there is a general religious toleration; indeed, in a town where there are various religious sects, some of which never administer baptism at all, and others who never administer it but to adults, which is our case, births can never be tolerably guessed at from an account of christenings. These however are not neglected, the gentlemen of the clergy having been so obliging as to furnish me with a compleat list of their several baptisms; from the same hands too, and from the Justices of the Peace, who by our laws are qualified

fied to marry, I am favoured with the number of couples married. The number of rateable polls, &c. I have from the assessor's list. I would further observe, that the year 1782, taking it throughout, was more sickly than ordinary, and I have great reason to think that we have not had so great a mortality, since the year 1773, which is the more remarkable, as no epidemic disorder has been uncommonly prevalent.

I should have been glad to have procured a more particular bill, as well as a more accurate one, but found it impracticable.

I am &c.

E. A. HOLYOKE.

Mr. CALEB GANNETT.

A Bill of Mortality for Salem, for the Year M,DCC,LXXXII.

GENERAL BILL.		December	13
Deaths	175		175
Births	317	BILL OF AGES.	
Baptisms	152	Still-born	6
Marriages	70	Within the month	6
Rateable polls, <i>i.e.</i> males, from 16 years old and upwards, resident in the town,	897	Between 1 mon. and 1 year	30
		1 year and 2	20
		2 and 5	22
		5 and 10	7
Transient persons—males,	200	10 and 15	3
		15 and 20	6
MONTHLY BILL.		20 and 25	5
January, died	21	25 and 30	7
February	11	30 and 40	24
March	9	40 and 50	10
April	12	50 and 60	7
May	8	60 and 70	2
June	11	70 and 80	7
July	11	80 and 90	6
August	12	Ages unknown, of chil- dren chiefly,	27
September	35		
October	22		
November	10		
			175

BILL

BILL OF DISEASES.

Angina	3	Putrid	1
Aphthæ	2	Nervous	2
Apoplexy	2	Rheumatic	1
Ascites	3	Hydrocephalus Internus	4
Asthma	1	Hypochondriacism	1
Atrophy	5	Lethargy	2
Cachexy	7	Lientery	1
Chin-Cough, combined		Old Age	7
with Dysentery and		Over-Eating	1
Cholera Dysenterica	7	Paralytic	6
Cholera Morbus	1	Phthisis Pulmonalis	13
Cholera Dysenterica	20	Ricketts	2
Coeliaca	1	Ulcers sinuous	1
Complicated Case	1	Vomiting	1
Consumption	4	Worms	1
Convulsion	7	Suddenly	5
Diarrhœa	3	New-born	6
Dysentery	6	Still-born	6
Empyema	1	Casualties 7, viz.	
Erysipelas	1	Burnt	3
Fevers	8	Drowned	1
Catarrhal	4	Frozen	1
Hospital	3	Over-laid	1
Pleuritic	2	Scalded	1
Peripneumonic	3	Diseases unknown of	13
			175

A Bill of Mortality for Salem, for the Year M,DCC,LXXXIII.

GENERAL BILL.		MONTHLY BILL.	
Deaths	189	January	5
Births, about	385	February	9
Baptisms { Boys 80 }	158	March	9
{ Girls 78 }		April	11
Marriages, about	84	May { Measles were {	33
Rateable polls, i. e. males, }	1000	June { epidemic {	24
from 16 years old and }		July	14
upwards		August	17
Number of inhabitants }	9000	September	25
estimated at about }		October	12
		November	

November	14	Empyema	1
December	16	Fevers	1
	189	From dentition	1
		Pleuritic	1
		Peripneumonic	5
		Rheumatic	2
		Scarlet	2
		Synochus	5
		From worms	1
		Hard Drinking	1
		Hæmoptosis	1
		Head mould-shot	1
		Hydrocephalus Internus	1
		Inflamed Intestines	1
		Imperforate Anus	1
		Lientery	1
		Lock'd-Jaw	1
		Measles	16
		After Measles, of Angina	2
		Fever	3
		Consumption	2
		Dysentery	2
		Peripneumony	7
		Sphacelus	1
		Synochus	1
		Old Age	5
		Oppression	1
		Paralytic	1
		Phthisis Pulmonalis	13
		Scrophulous Ulcers	2
		Suppressio Urinæ	1
		Spasm at Stomach	1
		Vomica	1
		Vomiting	2
		Worms	3
		New-born, <i>i. e.</i> within the } 11	
		month	
		Still-born	14
		Suddenly	2
		Shot dead	1
		Diseases unknown of	10
			189

BILL OF AGES.

Still-born	14
Within the month	11
Between 1 mon. and 1 year	27
1 year and 2	29
2 and 5	28
5 and 10	12
10 and 15	3
15 and 20	2
20 and 25	8
25 and 30	8
30 and 40	9
40 and 50	8
50 and 60	7
60 and 70	6
70 and 80	6
80 and 90	2
Ages unknown of	9
	189

BILL OF DISEASES.

Anasarca after Scarlet Fever	4
Angina	1
Apoplexy	3
Ascites	1
Asthma	2
Atrophy	4
Cachexy	2
Cancer	1
Child-birth	1
Cholera Dysenterica	8
Coeliaca	3
Complication	3
Consumption	5
Convulsions	8
Cynanche-maligna	5
Dysentery	6
Epilepsy	4

VI. *A History of a large Tumour, in the Region of the Abdomen, containing Hair.* By JOHN WARREN, Esq; F. A. A. and M. S. and Professor of Anatomy and Surgery in the University of Cambridge.

AN aversion to the making of large incisions, into such tumours as have appeared to have been seated within the cavity of the abdomen, has perhaps often been the reason, why those of them, which have happened to contain a substance less fluid than pus, have either induced a hectic, from a copious absorption of the thinner and more acrid parts; or, have speedily been followed by a fatal termination. The following history, may in some measure evince the safety of such large and free openings, in cases of this kind; but the facts contained in it, may also admit of an application to the purpose of explaining certain phenomena in the animal œconomy.

The production of hair in the human body, though it has often been the subject of accurate examination, and ingenious speculation, has perhaps never yet been satisfactorily accounted for; or to say the least, the solution is still destitute of that support and conviction, which in most other physiological inquiries, have so happily been attained.

Admitting the position, that many, if not all the interior parts of the body, are furnished with the necessary fluids for the growth of this substance, an accurate attention to the circumstances under which it is really produced, and to the nature of the parts in which it is most frequently found, must undoubtedly afford very considerable light on the subject; and from a large number of such facts, carefully and judiciously collected,

it is not improbable that every doubt and difficulty, attending the investigation, may be entirely removed.

Z—— H——, a negro woman, about thirty-two years of age, early in the year 1783, applied for medical assistance, in a case of a swelling in the abdomen, which had become extremely painful, and which began to be attended with very threatening symptoms. On examination, a very large tumour was found seated chiefly on the left side, occupying the whole space between the left *os ilium* and the left inferior ribs, and extending over to the right of the *umbilical region*, pointing a little to the left side of the navel, considerably hard, and extremely sensible. Upon inquiry into the origin of the tumour, it appeared, that the patient had first complained of pain in the left groin, and a general enlargement of the abdomen, immediately after delivery of her third child: This gradually increased after two successive labours, and since the birth of her last child, now about twelve years of age, had been almost constantly painful, though by no means in a very distressing degree, until about three weeks prior to her application for advice. At this period her complaints were greatly exasperated, in consequence of catching cold at the time of the catamenial evacuation, by which a total suppression was induced. The common discutient topical applications were immediately made use of; the usual methods were employed to renew the discharge; but all to no purpose. The swelling constantly increased for about three weeks, when an evident tendency to suppuration being perceived, the method of cure was immediately altered from a discutient to a suppurative process. In about two weeks, a fluctuation was perceptible, and at the end of two more, an opening into the cavity of the tumour was determined upon.

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An extensive incision was accordingly made through the *rectus* muscle, at a sufficient distance from the usual course of the *epi-gastric* artery to avoid all danger of wounding it, and about a pint of watery matter immediately issued through the orifice ; after which about the same quantity of pure pus was discharged.

On introducing two or three fingers into the cavity, a quantity of soft substance was felt within it, much about the consistency of soft soap. I immediately made use of a table-spoon, as the most convenient instrument that could be readily procured for extracting it, and about a pound of it was at this time obtained ; after which, as a degree of faintness began to ensue, the wound was dressed, and the patient placed in her bed, in a proper situation for admitting of a free discharge of any fluid that might still be retained.

At the three or four succeeding dressings, a portion of the same substance was taken out, till the whole being extracted, it amounted to the quantity of about four pounds.

At each dressing, the matter was particularly examined, and was found to contain a large quantity of short hair or wool, about three quarters of an inch long, uniformly mixed with it, as is seen in the specimen herewith presented for the inspection of the Academy.

In each hair was discoverable by the naked eye, a bulbous root, and a pointed extremity, both perfectly similar to what is seen in an intire hair produced naturally in other parts of the body. After the removal of the whole substance, the hand was passed into and round the cavity in search of bone, or any other foreign body which might be contained within it ; but though some of the gentlemen present, on supposition of an *extra-uterine fœtus*, expected to have found the former, yet nothing of

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either

either could be felt, though every part was fairly accessible. From this examination, it evidently appeared, that the matter extracted had been contained in a sac which firmly adhered to the *peritonæum*, a circumstance, I believe, generally attendant on suppurations in the viscera of the abdomen, as the natural consequence of previous inflammation.

On being exposed to the heat of the fire in an open vessel, it emitted a strong urinous smell, and was attended in other respects with most of the appearances usually exhibited in the broiling of animal substances. The action of flame produced a smart and continued decrepitation of the salt contained in it, until the whole was reduced to a simple coal; but no signs of inflammability, or the presence of any oily substance, were perceptible. When boiled, the water made use of in the process was very little changed as to its sensible properties; but after standing some time in a vessel to cool, it deposited a sediment which was suspected to be an alkaline salt, and which accordingly readily fermented with the vitriolic acid.

The patient, from the use of the bark, superficial dressings, and a restorative diet, was, in about three months, enabled to enter upon her usual employment, which was business of the most laborious kind. She had during her illness been much reduced, and for some time continued in an emaciated state, yet she now enjoys perfect health, and has become moderately corpulent. The catamenial evacuation has been regularly performed; but no signs of pregnancy have ever appeared, though before her sickness, she had borne children uncommonly fast.

Many of the practitioners in the town of *Boston* were called in to visit the patient, and various were the conjectures upon the nature

nature of the case. The absence of all the usual signs of pregnancy, except at those periods which regularly preceded the respective deliveries abovementioned, is a strong argument against the hypothesis of an *extra-uterine foetus*; and it should seem by no means admissible, that the bones should have been so perfectly dissolved as to have formed with the muscular, and other soft parts of a foetus, one uniform and apparently homogeneous mass of matter. Are we not authorized, from the general complexion of the case, particularly from the pain in the groin of the affected side, to pronounce the *ovarium* to have been the suffering part? The attachment of the *ligamentum rotundum* of the *uterus* to the adipose substance in the groin, seems to point out, either the *uterus*, or some other part connected with it, as the seat of the disorder.

A diseased *ovarium* may easily be conceived to acquire a size too great to admit of its being contained in the *pelvis*, and from its elevation in the abdominal region, the *uterus* itself might also be raised, and a distention of the ligament thereby be produced. But it is farther probable, that from an immediate adhesion of the *ovarium* to the neighbouring part of the *uterus*, the inflammation with which those parts might be affected, would extend to the ligament itself; the former cause operating in conjunction with this, would sufficiently account for the pain in the groin of the affected side; and the application of this reasoning in the above instance, together with the other facts contained in the history, might enable us, without much difficulty, to form a pretty sure diagnosis of the disease.



VII. *Experiments on the Waters of Boston.* By J. FERON. Surgeon-Major of his Most Christian Majesty's Squadron, under M. de TERNAY's Command in North-America, and of his Majesty's Marine Hospitals at Boston and in Rhode-Island, F. M. S.

WA T E R, a transparent, colourless, insipid body, commonly fluid, being part of the elementary composition of all bodies, excepting metals, and so essential to the existence and preservation of those into whose composition it enters, ought to be an object of careful attention.

That water which is a part of the elementary composition of bodies is pure ; if it was equally pure in the different repositories where we find it, it would need no analysis, it would every where produce the same invariable effects, for the purposes of animal and vegetable life, as well as in the various usés to which it is daily applied ; but as it is capable of dissolving many other substances, and of retaining them dissolved or suspended, we seldom find it pure ; it is always, more or less, loaded with foreign materials. These

Essais sur la Nature des Eaux de Boston. Par J. FERON, Chirurgien-Major de les Cadre de sa Majesté tres Chretienne, sous les Ordres de M. de TERNAY dans le Nord de l'Amerique, et de l'Hôpital de Marine de sa Majesté a Boston et a Rhode-Island, M. S. M.

L'EAU ce corps diaphane, insipide, sans couleur, ordinairement fluide, élément de tous les corps, exceptés les métaux, si essentiel à l'existence et à la conservation, des êtres dont il fait partie, doit être un objet digne de la plus grande attention.

L'eau qui entre comme élément dans la composition des corps est pure, si elle étoit telle dans les differens endroits où elle se rencontre, elle n'auroit pas besoin d'analyse, elle produiroit partout un effet constant, soit pour l'usage animal ou végétal, soit pour les differens usages auxquels on l'employe journellement, mais comme ce fluide est susceptible de dissoudre diverses substances, et de les tenir dissoutes ou suspendues, on le trouve rarement pur, il est toujours plus ou moins chargé de matieres étrangères. Ces matieres different en raison des endroits par où l'eau passe ou sejourne,

These materials differ according to the places through which the water passes, or in which it is collected, in such manner that it may be impregnated with one or many foreign principles which change its qualities, and render it in general prejudicial to health, and unfit for artificial uses, though, indeed, in some cases, they are favourable to both. Thus every one knows the efficacy of certain mineral waters in diseases, and the utility of the waters of certain rivers and lakes for the use of dyers; for instance, the advantage of mixing the waters of the *Rhone* and *Saone*, at *Lion*, for dying black, the water of the *Saone* alone for crimson, deep scarlet, cherry colour and violet, while those of the *Rhone* alone are preferred for white, green, grey, yellow, &c. the river of *Gobelins*, at *Paris*, for scarlet, and others for different colours. Many of these discoveries are the result of accident; for others we are indebted to analytical investigation. The analysis of water then, is an object of importance, both to medicine and the mechanic arts.

I

sejourne, desorte qu'elle peut être chargée d'une ou plusieurs substances étrangères à sa nature, qui altèrent ses qualités, et la rendent en général préjudiciable à la santé et aux arts quoique dans certains cas elles les favorisent; en effet personne n'ignore les bons effets de certaines eaux minérales dans plusieurs maladies, et de l'utilité qu'on tire, de celles de quelques lacs ou rivières, pour les teintures, tel qu'à *Lion*, les eaux du *Rhône* mêlées avec celles de la *Saône* pour le noir, l'eau de la *Saône* seule pour le cramoisi, le ponceau, le cerise, le violet, & les eaux du *Rhône* seul sont préférées, pour le blanc, le vert, le gris, le jaune, &c. la rivière des *Gobelins* à *Paris* pour la couleur écarlate, ainsi que d'autres pour différentes couleurs; plusieurs de ces connoissances sont dûes au hazard, mais on est redevable d'un grand nombre aux analyses. L'analyse des eaux semble donc être un objet qui mérite l'attention du médecin et de l'artiste.

Je ne promets pas de remplir la tâche que présente un travail aussi grand; j'exposerai seulement les diverses expériences que j'ai fait, et leur résultats, avec autant de circonspection.

I do not engage to enter at large into a work so extensive, I shall only relate the experiments I have made, and the result of them, with the necessary precision; and on the issue of these experiments, I shall form a determination of the qualities of the waters of *Boston*.

Sea water does not every where furnish the same residuum on evaporation. At *Boston* the result was as follows:

A pint* of water taken up at the head of *Long-Wharf*, left upon evaporation 6 drachms† 40 grains; this residuum being dissolved in distilled water and filtered, left 6 grains of calcareous earth on the filtre; the filtrated solution being evaporated, left 5 drachms 2 scruples of sea salt, with an alkaline basis; from 40 to 47 grains of sea salt, with the terrene basis, or *sal. cathart. amar.* and a small quantity of oil.

Pump water being in general use, particularly engaged my attention; it is more or less charged with heterogeneous parts in proportion

* *The pint was equal to an English quart.*

† *The Drachm mentioned contains 72 grains.*

circonspection que la nature du travail exige, ces résultats me serviront de guide pour former un jugement sur la nature des eaux de *Boston*.

Les eaux de la mer ne fournissant pas partout le même résidu par l'évaporation, je vais mentionner ce qu'elles m'ont donné à *Boston*.

Une pinte * d'eau prise à la tête du *Long-Wharf*, m'a fourni après l'évaporation six gros † et quarante grains de résidu, les quels ayant été dissous dans l'eau distillée a laissé sur le filtre six grains de terre calcaire, l'eau évaporée a rendue cinq gros deux scrupules de sel marin à base d'alkali, quarante à quarante sept grains de sel marin à base terreuse ou cathartique amer, et une petite quantité d'huile.

L'eau de pompe étant celle dont on fait un usage plus fréquent, à fixé plus particulièrement mon attention; elle est plus ou moins chargée de parties hétérogènes conformément à sa proximité avec la mer; ainsi celle des endroits bas est moins pure que

* *Une pinte d'eau égale au quart de Boston.*

† *Le gros de soixante douze grains.*

proportion to its proximity to the waters of the ocean. That in low situations, is less pure than the water in more elevated grounds; it generally contains the same principles, except such as have a superabundance of calcareous earth. Among such as I examined, the water of *Beacon-hill*, *Charter-Street*, and some in *New-Boston*, appeared most free from impurities. The weight was generally from 15 to 40 grains above that of distilled water; the thermometer standing in the open air at 32° , rose to 40 and 46 on being immersed, those which contained the most impurities being warmest. These waters have a brackish taste to strangers, and the inhabitants themselves are sensible of it on drinking the purer element, which seems soft and insipid; they are hard and do not dissolve soap. I began with determining by the alkaline lixivium used in making Prussian blue, whether they contained any metallic principle; and being satisfied that they did not, I made the following experiments: I put into two separate vials, equal parts of distilled water and of pump water, and having added to each an equal quantity of pulverized rhubarb,

que celle des lieux élevés, elle contient généralement partout les mêmes principes, exceptés quelques unes qui sont sur-chargées d'une quantité de terre calcaire; parmi celles que j'ai analysées celle de *Beacon-Hill*, *Charter-Street*, et quelque une de *New-Boston* m'ont paru les moins impures. Leur poids est depuis quinze jus qu'à quarante grains par pinte plus pesante que l'eau distillée, le thermomètre étant à l'air libre à trente deux, a monté à quarante et quarante cinq, par immersion; celles qui contenoient le plus de parties hétérogènes étoient les plus chaudes.

Ces eaux ont un gout unpeu saumâtre pour les étrangers, dont les habitans de *Boston* s'apperçoivent quand ils en boivent de plus pure la quelle ils trouvent fade et trop douce. Elles sont dures au toucher et ne dissolvent pas le savon.

Je commençais d'abord par m'assurer au moyen de la lessive alkaline pour le bleu de Prusse, de l'existence ou non-existence d'une substance métallique quelconque; persuadé qu'il ny en avoit pas, je fis les expériences suivantes.

rhubarb, I exposed them to the same degree of heat. The distilled water gave a fine yellow tincture, but in the other it was a deep yellow, inclining to red. The same experiment was made with cochineal, the one yielding a fine red, the other a deeper colour, verging to crimson, afterwards the colouring particles were precipitated, partly or intirely, according to the quantity of water. Logwood, instead of a lively, gave only a dull red, inclining to crimson; and with beet-juice the result was the same. Nutgalls gave out a tinge of their own colour in pure water, it was darker and more opaque in pump water, and a small addition of the fixed alkali turned it to a deep green.

These experiments seem already to indicate the nature of a salt with an earthy basis, having some marks of the marine acid. I poured upon a quantity of water, a solution of silver in the nitrous acid; there was immediately formed a white cloud, which soon after became pearl coloured, and then of a darkgrey; a solution of mercury, in the same menstruum, produced a cloud and
white

Je mis separement dans de deux bouteilles, parties égales de l'eau distillée et de l'eau de pompe, j'ajoutai dans chaque le meme poids de rhubarbe en poudre, et les exposai au même degré de chaleur; l'eau distillée a donné une teinture d'un beau jaune, tandis que l'autre a produit un jaune foncé tirant sur le rouge.

La même expérience a été faite avec la cochenille, l'une a fourni un beau rouge, et l'autre a donné d'abord un rouge foncé qui aussitôt passa au cramoisi, ensuite la partie colorante a été précipitée en grande partie, ou entièrement, selon la qualité de l'eau; le bois de campêche au lieu de fournir une teinture d'un beau rouge, a donné un rouge foncé et cramoisi. Le suc de bette rouge a produit le même effet. La noix de galle a fourni une teinture de sa couleur dans l'eau pure, elle a été plus foncé et opaque avec l'eau de pompe, et bien peu d'alkali fixe la rendoit d'un vert foncé.

Ces expériences semblent déjà indiquer la nature d'un sel à base terreuse, donnant quelques indices d'acide marin.

white precipitate : a solution of the fixed alkali, or the alkali fluor, produced a white cloud, and the precipitate was about six grains to a pint ; it dissolved in acids with effervescence. Some of these waters (that of the cold bath in *Water-Street* for instance) being put into bottles, a quantity of air was perceived rising in bubbles to the surface, and, by rest, was entirely dissipated, and then there might be discovered a small sediment. Lime-water dropped into these waters, formed a white cloud, and detached a precipitate of the same colour.

The water of *Beacon-hill*, and *Charter-Street*, gave no such precipitate with the alkalies nor with lime-water.

Does not the precipitation formed by the lime-water, joined to the air-bubbles, and the sediment taking place on their escape, indicate an earth suspended by means of a superabundance of air ?

I proceeded next to evaporation ; a pint gave from 10 to 36 grains of a saline earthy residuum, of a yellowish colour, which left

Je versai sur une quantité d'eau, quelques gouttes de dissolution d'argent par l'acide nitreux, il se forma sur le champ un nuage blanc qui bientôt apres devint couleur de perle, et ensuite gris foncé ; la dissolution de mercure par le même acide donnoit un nuage et précipité blanc ; une dissolution d'alkali fixe, ou l'alkali fluor faisoit paroître un nuage blanc et le précipité étoit d'environ six grains par pinte, il se dissolvoit dans les acides avec effervescence ; quelques unes des eaux tel que celle de *Water-Street* ; * par exemple, mises dans des bouteilles laissoient appercevoir une grande quantité de bulles d'air qui montoient à la surface et se dissipoient par le repos ; on appercevoit alors un peu de sediment, l'eau de chaux versée goûte à goûte dans ces eaux, formoit un nuage blanc, et laissoit déposer un précipité de la même couleur ; les eaux de *Beacon-Hill* et de *Charter-Street* ci devant mentionnées, ne fournissoient point ce précipité avec les alkali, ni avec l'eau de chaux.

Le précipité que forme l'eau de chaux joint aux bulles d'air que l'on apperceoit et au sediment qui suit leur evasion, ne semblent ils pas demontrer une terre suspendue au moyen d'une surabondance d'air ? Je

* Cold Bath.

left on the tongue a saltish disagreeable taste; thrown on a red-hot iron in the fire, there was no decrepitation; exposed to the air, it swelled and grew white, attracting a little moisture.

A drachm and 12 grains of this residuum dissolved in distilled water, left on the filter 19 grains of a greyish earth, which was in part soluble in the nitrous and marine acids, but less so in the vitriolic, it was precipitated from the two former by the last. Having evaporated the liquor to a pellicle, it gave no regular crystals by cooling nor evaporation; a saline pellicle was formed on the liquor, which I broke to forward the crystallization of what remained; this was of a yellowish colour, and compleatly exsiccated with great difficulty. This saline substance was neither acid nor alkaline, it left a saltish impression on the tongue, and a copperish taste, decrepitated a little on the coals, and dissolved easily in water. Fixed or volatile alkali added to this solution, caused no sudden change, but a precipitation ensued soon after. Pouring upon this salt, the marine or nitrous acids,

Je procedai ensuite à l'évaporation, une pinte m'a fourni depuis dix jusqu'à trente six grains de résidu salin terreux de couleur jaunâtre, qui laissoit sur la langue une impression salée désagréable, jetté sur un fer rougi au feu, ne décrepitoit pas, s'enflloit et blanchissoit, exposé à l'air il attiroit un peu l'humidité.

Un gros et douze grains de ce résidu, dissous dans l'eau distillée a laissé sur le filtre dix-neuf grains de terre grisâtre, laquelle étoit en partie soluble dans les acides nitreux et marin, et le paroissoit moins dans le vitriolique, elle étoit cependant précipité des deux premiers par le dernier.

Ayant évaporé la liqueur jusqu'à pellicule elle n'a point donnée de cristaux réguliers par le refroidissement, ni l'évaporation, une pellicule saline assez épaisse s'est formé sur la liqueur que j'ai rompu pour permettre la cristallification du reste, qui ne s'est faite que par deséchement et de couleur jaunâtre, difficile à secher, cette substance saline n'étoit ni acide ni alkaline, elle laissoit une impression salée sur la langue et un espece de goût cuivreux, décrepitoit un peu sur les charbons, se

acids, no motion was excited; but the vitriolic raised a considerable fermentation, with vapours like those where this acid is poured on dried sea salt. This salt, exposed to the air, attracted moisture; but not so readily as that of which we shall presently treat.

From these various experiments, may we not conclude that the waters of *Boston* contain a sea salt with a basis of mineral alkali in small quantity, a greater quantity of sea salt with an earthy basis, a certain quantity of oil, perhaps a little of *sal catharticus amarus*.

There are besides some which contain farther a superabundance of earth, suspended by means of an undue proportion of air.

To arrive at greater certainty, and make my experiments more decisive, I combined sea salt with an earthy basis, by mixing powder of coral with the marine acid; the crystallization was

Y y y 2

like

se dissolvoit aisément dans l'eau; l'alkali fixe ou volatile ajouté à cette dissolution n'occasionnoit pas de changement subit, mais quelque tems apres, un precipité; en versant sur ce sel de l'acide marin ou nitreux il ne paroissoit aucun mouvement; mais si on se servoit du vitriolique, il excitoit une fermentation considerable, avec des vapeurs semblables à celles que ce même acide occasionne lors qu'on le verse sur du sel marin deseché; ce sel exposé à l'air attiroit l'humidité, cependant pas aussi promptement que celui dont je parlerai ci apres.

D'apres ces diverses experiences ne peut on pas conclure, que les eaux de *Boston*, contiennent un sel marin a base d'alkali minéral en petite quantité, une plus grande de sel marin a base terreuse, une certaine quantité d'huile, peut être un peu de sel cathartique amer.

En outre, il en est qui contiennent deplus une sur abondante quantité de terre, laquelle m'a parue suspendue au moyen d'une trop grande quantité d'air.

Pour m'assurer plus positivement et rendre mes experiences plus certaines, je combinai un sel marin à base terreuse au moyen de la poudre de corail unie à l'acide marin,

like that of the preceding salt ; it was whiter, arising, I suppose, from a difference in the quantity of oil ; it more readily absorbed moisture, because it was not combined with salt of an alkaline basis, it did not decrepitate on the coals for the same reason ; in other respects, it exhibited the same appearances with the preceding salt.

Much remains to be said, but time and circumstances prevent my enlarging. If this sketch shall be thought of utility, I shall be very agreeably recompenced.

marin, la cristallisation a été la même que celle du sel précédent, mais il étoit plus blanc, cela depend, je crois, d'une difference huileuse, il attiroit plus promptement l'humidité de l'air par ce qu'il n'étoit point mêlé de sel à base d'alkali, il ne décrepitoit point sur les charbons par la même raison, au reste, il présentoit les mêmes phénomènes que le précédent.

Il reste encore beaucoup des choses à dire que le tems ni les circonstances ne me permettent pas à présent ; heureux si cet esquisse peut être utile, il deviendra pour moi une récompense bien flatteuse.



VIII. *Observations on the Longevity of the Inhabitants of Ipswich and Hingham, and Proposals for ascertaining the Value of Estates held for Life, and the Reversion of them. In a Letter from the Rev. EDWARD WIGGLESWORTH, F. A. A. and Hollisian Professor of Divinity in the University of Cambridge, to the Honourable JAMES BOWDOIN, Esq; Pres. A. A.*

Cambridge, January 28, 1782.

HON. SIR,

AFTER the last meeting of the Academy, the Rev. Mr. Cutler, of Ipswich-Hamlet, put into my hands a bill of the births and deaths in his parish, from September 11, 1771, to September 11, 1781. This bill has been kept with great accuracy; and it serves to shew, so far as a general conclusion can be drawn from the births and deaths in a single parish, that either the climate, or the manner of living on the sea-coast of *New-England*, is very favourable to life.

From the situation of *Breslaw*, and the employment of its inhabitants, Doctor *Halley* supposes that the deaths in that city are more proper for tracing out the probabilities of the continuance of the human life in its various stages, than those of any other large city in *Europe*. His table has accordingly been made the standard for estimating the value of those estates in *Great-Britain* which are held for life.

The Doctor observes, that the people of *Breslaw* are increased by 1238 births annually. Of those it appears, by Dr. *Newman's* tables, that 348 die yearly, in the first year of their age; so that but 890 do arrive at a full year's age; and that 193 die in five years, between one and six, complete; so

so that 692 of the persons born, survive six whole years, and but 710 survive five whole years. Hence it follows, that at *Breslaw* five persons out of twelve that are born, die before they have completed the fifth year of their age. Whereas at *Ipswich-Hamlet*, where, in the course of ten years, 331 persons have been born, but 60 died before they had completed the fifth year; that is but 6 in 33; which determines *Ipswich-Hamlet* to be more than twice as favourable as *Breslaw*, for the preservation of life in its first stages. A similar conclusion may be made with respect to the late periods of life. For by Dr. *Halley's* table, out of 1000 persons who die annually at *Breslaw*, but 34 survive 80 years complete. Whereas at *Ipswich-Hamlet*, out of 164 persons who have died in ten years, 21 persons have survived 80 years complete. At the former place, one in about 30; at the latter, one in about 8 arrive at this great age.

Mr. *Lincoln*, eldest son of the Hon. Major-General *Lincoln*, has been so kind as to favour me with a copy of the Rev. Mr. *Gay's* bills of the baptisms, marriages and burials, in the first parish in *Hingham*, from 1726 to 1779, inclusive. This aged and venerable gentleman has been exceedingly accurate in keeping those bills. The age of every person who has died in his parish for 54 years, is set down in the order of the deaths. This bill will be very serviceable in computing a table of the probabilities of the continuance of life in *New-England*, possibly more so than any others that can be obtained,

This bill I have reduced to the respective years of the human life, and by this means have determined the particular number that have died in each age. From the reduction, it appears, that *Hingham*, as well as *Ipswich*, is more favourable to longevity

vity than *Breslaw*, the *British* standard of life. At the first parish in *Hingham*, in a period of fifty-four years, 2247 persons have been born; there have been 521 marriages, and 1113 deaths. Of those, 168 have died in the first year, and 404 under five years complete. Out of 1113 persons who have died in 54 years in that parish, 84 persons have survived 80 years complete; whereas at *Breslaw* only 34 out of 1000 survived that age.

These speculations are not designed as a *mere amusement*; they are intended for a *valuable purpose in civil life*. The value of those estates which are held for life, and the reversion of them, can only be determined by knowing the probability which there is, that their respective holders will live for a longer or shorter term of years. Those probabilities are different in different periods of life. The present value of two estates held in dower, whose annual incomes are equal, may be very different. For instance, a widow of 30 years of age has an equal chance of living, according to Dr. *Halley's* table, about 28 years; whereas one of 50 years has only an equal chance of living 17 years. The present value, therefore, of the estates held by them respectively, as well as the value of their reversion; though their annual incomes should be equal, are very different. There has, as yet, been no certain rule established for estimating the value of such estates. Whenever a widow has compounded with the heirs of an estate for a sum of money in lieu of her dower, the composition has been made at random, and not on any fixed principles that have determined it to be equitable.

From the comparison made above, it is evident, that the present value of estates among us, held for life, and the value of the reversion of such estates, cannot be traced with accuracy from the

the *European* tables. If ever it should be effected, tables must be constructed among ourselves; and this can only be done by keeping regular bills of mortality, comparing them together, and making proper deductions from their joint result.

It is therefore to be wished, that those gentlemen who have such bills in their possession, or have it in their power to procure them, would communicate them to the Academy at some future meeting.

I have inclosed the Rev. Mr. Cutler's bill, mentioned already, with a request that I may be permitted to take a copy of it. Those of the Rev. Mr. Gay, I have been prevented, by ill health, from putting into proper order for laying them before the Academy at their present meeting; but hope to be able to do it before the next meeting of the society.

I am, &c.

EDWARD WIGGLESWORTH.

Honourable James Bowdoin, Esquire.



END OF THE FIRST VOLUME.